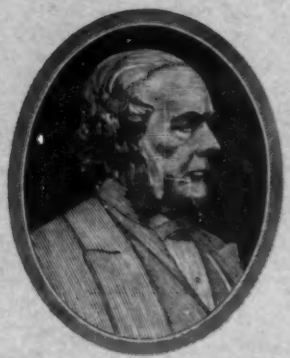
VOL. XLVII ISSUED IN ALTERNATE MONTHS No. 206

The British Journal of Surgery



LISTER

MAY, 1960

BRISTOL: JOHN WRIGHT & SONS LTD.

WHOLESALE DISTRIBUTORS WM. DAWSON & SONS LTD.
10-12 MACKLIN STREET LONDON W.C.2

UNITED STATES OF AMERICA: THE WILLIAMS & WILKINS COMPANY, BALTIMORE, *Sole Agents*

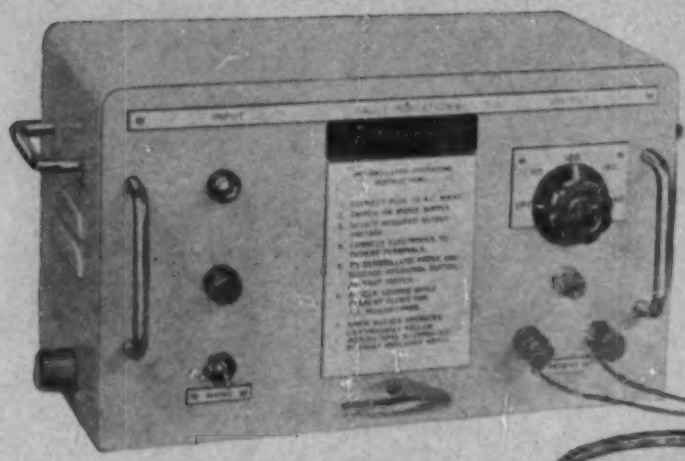
Entered as second class matter at the Post Office at BALTIMORE under Act of March 3, 1879.

ALLEN & HANBURYS LTD

introduce

THE SEALEY Portable

DEFIBRILLATOR



MODEL P.D.2

—ready for immediate use in cardiac emergencies

DESCRIPTIVE LITERATURE AVAILABLE ON REQUEST

NOTE: This Portable Defibrillator is only one of a comprehensive range of Sealey Electrical Cardiac Resuscitation Apparatus, including internal and external defibrillators and cardiac pacemakers.

SOLE WORLD DISTRIBUTORS

ALLEN & HANBURYS LTD *(SURGICAL DIVISION)* LONDON E2

THE BRITISH JOURNAL OF SURGERY

UNDER THE DIRECTION OF THE FOLLOWING EDITORIAL COMMITTEE

*SIR JAMES PATERSON ROSS, BT. (London), *Chairman*

IAN AIRD (London)
*HEDLEY ATKINS (London)
J. C. BARRETT (Leicester)
GERALDINE M. BARRY (London)
MICHAEL BOYD (Manchester)
SIR RUSSELL BROCK (London)
EARDLEY BUTTON (Wellington)
SIR STANFORD CADE (London)
DIGBY CHAMBERLAIN (Leeds)
SURGEON CAPTAIN H. L. CLEAVE (Naval Medical Service)
A. J. CRAIG (Malta)
V. W. DIX (London)
AIR VICE-MARSHAL SIR PETER DIXON (Royal Air Force Medical Branch)
WILLIAM DOOLIN (Dublin)
D. M. DOUGLAS (St. Andrews)
PROFESSOR D. J. DU PLESSIS (Johannesburg)
*HAROLD EDWARDS (London)
*SIR ERNEST FINCH (Sheffield)
W. GISSANE (Birmingham)
GEOFFREY HADFIELD (London)
C. S. HALLPIKE (London)
C. F. W. ILLINGWORTH (Glasgow)
T. G. ILLTYD JAMES (London)
T. P. KILNER (Oxford)
E. F. KING (London)
L. C. E. LINDON (Adelaide)
J. LOEWENTHAL (Sydney)
J. H. LOUW (Cape Town)
I. W. J. McADAM (Colonial Medical Service)
J. A. MacFARLANE (Toronto)
*SIR RALPH MARNHAM (London)
S. J. MEHTA (Bombay)
COLONEL S. A. MIAN (Rawalpindi)
T. McW. MILLAR (Edinburgh)
C. NAUNTON MORGAN (London)
D. W. C. NORTHFIELD (London)
B. H. PAGE (London)
V. L. PARMAR (Bombay)
MILROY PAUL (Colombo)
VERNON PENNELL (Cambridge)
R. S. PILCHER (London)
*SIR ARTHUR PORRITT (London)
R. W. REID (Colchester)
*SIR ERIC RICHES (London)
C. G. ROB (London)
DOUGLAS ROBB (Auckland)
H. R. ROCKE ROBERTSON (Montreal)
R. H. O. B. ROBINSON (London)
H. W. RODGERS (Belfast)
LAMBERT ROGERS (Cardiff)
HENRY SEARBY (Melbourne)
H. J. SEDDON (London)
D. SLOME (London)
F. A. R. STAMMERS (Birmingham)
BRIGADIER R. A. STEPHEN (Army Medical Services)
N. C. TANNER (London)
J. TAYLOR (Khartoum)
*R. MILNES WALKER (Bristol)
CHARLES WELLS (Liverpool)
A. HEDLEY WHYTE (Newcastle upon Tyne)
W. C. WILSON (Aberdeen)
R. F. WOOLMER (London)

*SIR CECIL WAKELEY, BT. (London), *Editorial Secretary*

*Constitute the Executive Committee

MAY, 1960

ISSUED IN ALTERNATE MONTHS
Subscription 84/- per annum, post free

BRISTOL: JOHN WRIGHT & SONS LTD.
WHOLESALE DISTRIBUTORS: WM. DAWSON & SONS LTD.,
10–12 MACKLIN STREET, LONDON, W.C.2

TORONTO: THE MACMILLAN CO. OF CANADA LTD. SYDNEY: ANGUS AND ROBERTSON LTD.
UNITED STATES OF AMERICA: THE WILLIAMS AND WILKINS COMPANY, BALTIMORE, *Sole Agents*

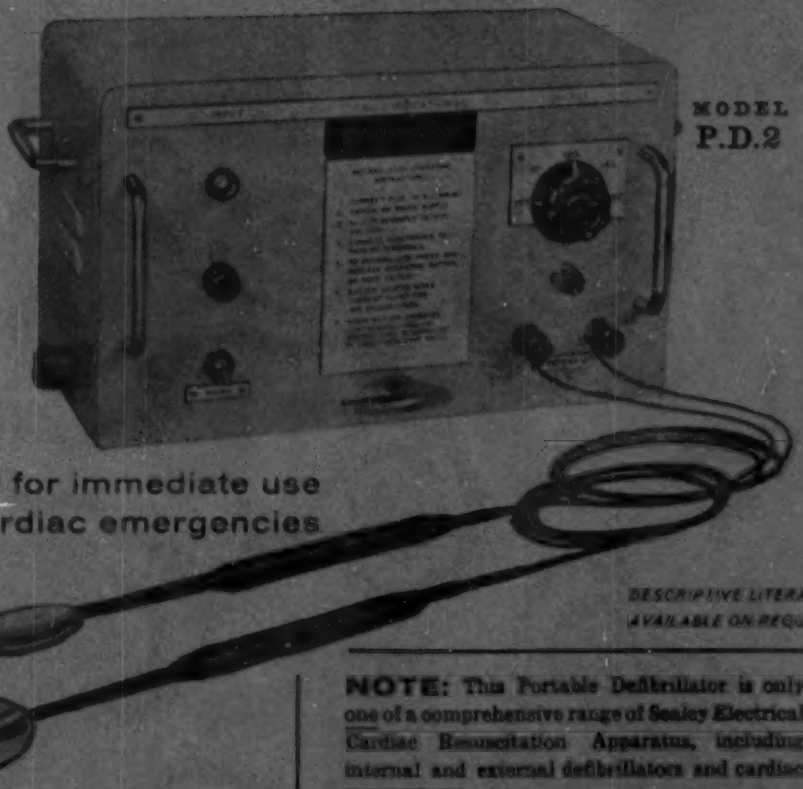
A

ALLEN & HANBURYS LTD

introduce

THE SEALEY Portable

DEFIBRILLATOR



MODEL P.D.2

—ready for immediate use in cardiac emergencies

DESCRIPTIVE LITERATURE AVAILABLE ON REQUEST

NOTE: This Portable Defibrillator is only one of a comprehensive range of Sealey Electrical Cardiac Resuscitation Apparatus, including internal and external defibrillators and cardiac pacemakers.

SOLE WORLD DISTRIBUTORS

ALLEN & HANBURYS LTD (SURGICAL DIVISION) LONDON E2

THE BRITISH JOURNAL OF SURGERY

UNDER THE DIRECTION OF THE FOLLOWING EDITORIAL COMMITTEE

*SIR JAMES PATERSON ROSS, BT. (London), *Chairman*

IAN AIRD (London)
*HEDLEY ATKINS (London)
J. C. BARRETT (Leicester)
GERALDINE M. BARRY (London)
MICHAEL BOYD (Manchester)
SIR RUSSELL BROCK (London)
EARDLEY BUTTON (Wellington)
SIR STANFORD CADE (London)
DIGBY CHAMBERLAIN (Leeds)
SURGEON CAPTAIN H. L. CLEAVE (Naval Medical Service)
A. J. CRAIG (Malta)
V. W. DIX (London)
AIR VICE-MARSHAL SIR PETER DIXON (Royal Air Force Medical Branch)
WILLIAM DOOLIN (Dublin)
D. M. DOUGLAS (St. Andrews)
PROFESSOR D. J. DU PLESSIS (Johannesburg)
*HAROLD EDWARDS (London)
*SIR ERNEST FINCH (Sheffield)
W. GISSANE (Birmingham)
GEOFFREY HADFIELD (London)
C. S. HALLPIKE (London)
C. F. W. ILLINGWORTH (Glasgow)
T. G. ILLTYD JAMES (London)
T. P. KILNER (Oxford)
E. F. KING (London)
L. C. E. LINDON (Adelaide)
J. LOEWENTHAL (Sydney)
J. H. LOUW (Cape Town)
I. W. J. McADAM (Colonial Medical Service)
J. A. MACFARLANE (Toronto)
*SIR RALPH MARNHAM (London)
S. J. MEHTA (Bombay)
COLONEL S. A. MIAN (Rawalpindi)
T. McW. MILLAR (Edinburgh)
C. NAUNTON MORGAN (London)
D. W. C. NORTHFIELD (London)
B. H. PAGE (London)
V. L. PARMAR (Bombay)
MILROY PAUL (Colombo)
VERNON PENNELL (Cambridge)
R. S. PILCHER (London)
*SIR ARTHUR PORRITT (London)
R. W. REID (Colchester)
*SIR ERIC RICHES (London)
C. G. ROB (London)
DOUGLAS ROBB (Auckland)
H. R. ROCKE ROBERTSON (Montreal)
R. H. O. B. ROBINSON (London)
H. W. RODGERS (Belfast)
LAMBERT ROGERS (Cardiff)
HENRY SEARBY (Melbourne)
H. J. SEDDON (London)
D. SLOME (London)
F. A. R. STAMMERS (Birmingham)
BRIGADIER R. A. STEPHEN (Army Medical Services)
N. C. TANNER (London)
J. TAYLOR (Khartoum)
*R. MILNES WALKER (Bristol)
CHARLES WELLS (Liverpool)
A. HEDLEY WHYTE (Newcastle upon Tyne)
W. C. WILSON (Aberdeen)
R. F. WOOLMER (London)

*SIR CECIL WAKELEY, BT. (London), *Editorial Secretary*

*Constitute the Executive Committee

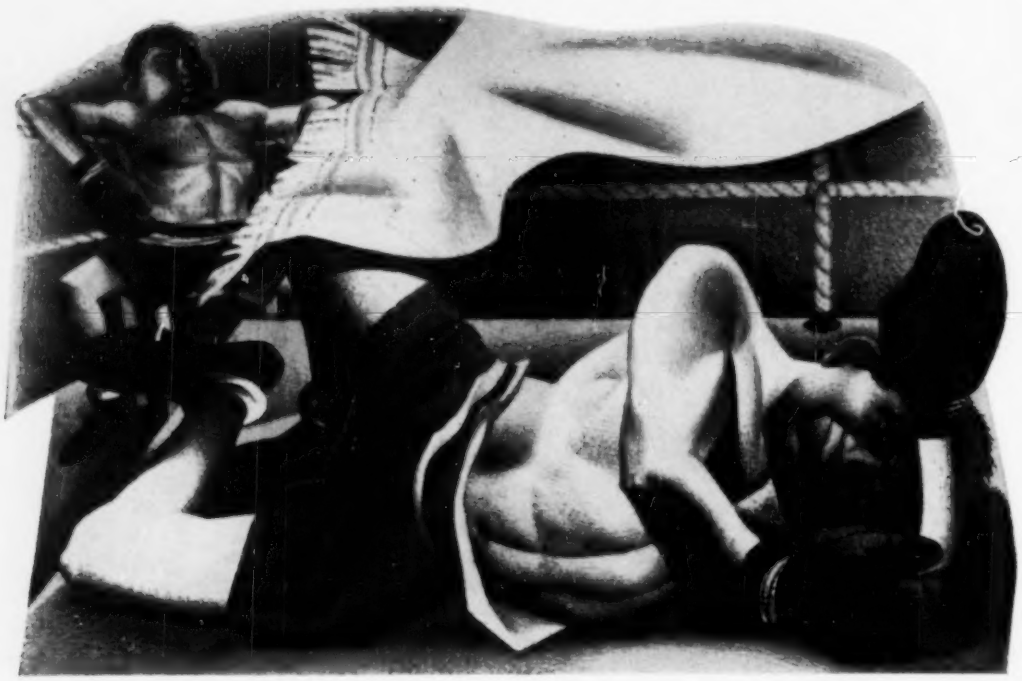
MAY, 1960

ISSUED IN ALTERNATE MONTHS
Subscription 84/- per annum, post free

BRISTOL: JOHN WRIGHT & SONS LTD.
WHOLESALE DISTRIBUTORS: WM. DAWSON & SONS LTD.
10-12 MACKLIN STREET, LONDON, W.C.2

TORONTO: THE MACMILLAN CO. OF CANADA LTD. SYDNEY: ANGUS AND ROBERTSON LTD.
UNITED STATES OF AMERICA: THE WILLIAMS AND WILKINS COMPANY, BALTIMORE, *Sole Agents*

a time for relaxation . . .



A short time or a long time for muscular relaxation?
B. W. & Co. provide a product for each need:

'ANECTINE' BRAND Injection of Succinylcholine Chloride

The first choice for procedures requiring rapid muscular relaxation of brief duration.

'TUBARINE' BRAND Preparations of Tubocurarine Chloride

The most widely-used muscle relaxant; unsurpassed for prolonged procedures, and where profound relaxation is required.

B. W. & CO. Muscle Relaxants

BURROUGHS WELLCOME & CO. (The Wellcome Foundation Ltd.) LONDON

The British Journal of Surgery

CONTENTS, MAY, 1960

ORIGINAL PAPERS

		PAGE
Sensory Nerve-endings and Sensation in the Anal Region of Man	*H. L. Duthie and F. W. Gairns*	585
Radiation in the Management of Keloids and Hypertrophic Scars	*H. A. S. Van den Brenk and C. C. J. Minty*	595
The Management of Carotid Body Tumours	*G. Westbury*	605
Intervertebral Disk Protrusions in Childhood and Adolescence	*John E. A. O'Connell*	611
Extended Right Hemicolectomy	*H. W. Gallagher*	616
Adenocarcinoma of the Appendix	*G. H. Cook and B. P. Flannery*	621
Multiple Carcinoid Tumours of the Ileum	*Charles G. Clark and R. N. Curnow*	624
Antecubital Strings—A New Physical Sign?	*H. H. G. Eastcott*	629
Ureteric Reflux in the Paraplegic	*J. Cosbie Ross, Marek Damanski, and Norman Gibbon*	636
The Management of Acute Intestinal Obstruction	*Paul T. Savage*	643
The Reliability of Telepaque Cholecystography	*D. A. Alderson*	655
Leukæmic Infiltration of the Prostate	*John R. Tighe*	658
Common Bile-duct Suture without Intraductal Drainage following Choledochotomy	*Patrick G. Collins, Charles R. M. Redwood, and Geoffrey Wynne-Jones*	661
Wounds of the Heart	*N. A. Blumberg*	667
Two Cases of Ureteric Tumour with Unusual Pyelographic Findings	*L. Stuart Scott and A. Douglas Roy*	678

EXPERIMENTAL SURGERY

Mechanisms preventing Gastro-œsophageal Reflux in the Dog	*F. G. Smiddy and M. Atkinson*	680

SHORT NOTES OF RARE OR OBSCURE CASES

Two Cases with Unusual Causes of Obstruction of the Common Bile-duct	*F. A. R. Stammers*	687
Metaplasia in a Nerve-sheath Sarcoma in von Recklinghausen's Disease	*Richard A. Payne*	688
Jejunal Diverticulosis as a Cause of Intestinal Obstruction	*W. B. N. Bomford*	690

REVIEWS AND NOTICES OF BOOKS

Bibliography of Cancer produced by Pure Chemical Compounds—*Otto Neubauer*. I Diverticoli dell'Esofago—*Giulio R. Bettolo and Guido Franzini*. Hermaphroditism, Genital Anomalies and Related Endocrine Disorders—*Howard W. Jones, jun., and William Wallace Scott*. A Short Practice of Surgery—*Hamilton Bailey, McNeill Love, John Charnley, William Cleland, and Geoffrey Knight*. Prophylaxie et Traitement des Escarres de Decubitus—*R. Vilain*. Zum Krankheitsbild des Sogenannten Cardiospasmus—*P. C. Ahnor*. The Human Spine in Health and Disease—*Georg Schmorl and Herbert Junghanns*. Tools of Biological Research—ed. *Hedley J. B. Atkins*. The Biochemical Response to Injury—ed. *H. B. Stoner*. Actualités de Chirurgie Orthopédique et Reparatrice—ed. *Merle D'Aubigné*. The Cell of Schwann—*Gilbert Causey*. British Medical Bulletin, vol. 16, No. 1, January 1960. British Surgical Practice, Surgical Progress 1959—ed. *Sir Ernest Rock Carling and Sir James Paterson Ross* 693

© JOHN WRIGHT & SONS LTD., 1960

EDITORIAL NOTICES

EDITORIAL COMMUNICATIONS should be addressed to the *Editorial Secretary, British Journal of Surgery, c/o John Wright & Sons Ltd., Bristol.*

Original Articles are invited, and should be sent, whenever possible, to a member of the Editorial Committee: they are accepted with the understanding that they are contributed to this Journal only, and that articles and their illustrations become the property of the Journal unless the authors state, before publication, that they reserve the rights to themselves. Authors are asked to ensure that original illustrations are securely packed and adequately protected.

REPRINTS can be supplied at a reduced price if authors will indicate their requirements at the time that proofs are returned. The following scale will be helpful as a guide to the cost; 50 copies are suggested as a minimum number.

PAGES	NUMBER REQUIRED														
	50		100		150		200		250		300		400		500	
2	£1	0 0	£1	5 0	£1	10 0	£1	14 0	£1	17 0	£ 2	0 0	£ 2	5 0	£ 2	10 0
4	1	15 0	2	4 0	2	13 0	3	0 0	3	5 0	3	10 0	3	19 0	4	8 0
6	2	10 0	3	2 6	3	15 0	4	5 0	4	12 6	5	0 0	5	12 6	6	5 0
8	3	0 0	3	15 0	4	10 0	5	2 0	5	11 0	6	0 0	6	15 0	7	10 0
10	3	10 0	4	7 6	5	5 0	5	19 0	6	9 6	7	0 0	7	17 6	8	15 0
12	4	0 0	5	0 0	6	0 0	6	16 0	7	8 0	8	0 0	9	0 0	10	0 0
14	4	10 0	5	12 6	6	15 0	7	13 0	8	6 6	9	0 0	10	2 6	11	5 0
16	5	0 0	6	5 0	7	10 0	8	10 0	9	5 0	10	0 0	11	5 0	12	10 0
Printed Covers	£	15 0	£1	0 0	£1	5 0	£1	10 0	£1	15 0	£ 2	0 0	£ 2	10 0	£ 3	0 0

An additional charge will be made for reprints containing coloured illustrations, depending upon the amount of extra work involved.

BUSINESS COMMUNICATIONS should be addressed to *John Wright & Sons Ltd., British Journal of Surgery, Bristol.* Remittances should be made payable to *The British Journal of Surgery.*

BINDING.—Handsome Cloth Cases may be obtained for binding Vol. xlvi. Cases are also available for some of the earlier volumes. Applications should be made to the Publishers, who will also undertake the binding if desired. Case 8s. 6d., post free; Case and binding 21s., post free.

BACK NUMBERS.—The Publishers would be glad to purchase copies in good condition of No. 179, Vol. xliii; No. 180, Vol. xliii; No. 181, Vol. xliii; No. 187, Vol. xliv; No. 188, Vol. xliv; No. 189, Vol. xlv; No. 190, Vol. xlv; and No. 191, Vol. xlv.

INSTRUCTIONS TO AUTHORS

PREPARATION OF MS.—Papers should be submitted in typescript and the author should retain a carbon copy. Double spacing should be used throughout, except for quotations.

TABLES AND ILLUSTRATIONS.—Tables should be numbered in roman numerals and set out on sheets separate from the text. Illustrations, too, should be kept separate from the text and should be numbered consecutively in arabic numerals. Each figure should be referred to in the text, and the descriptive legends should be typewritten on a separate sheet of paper, and not put on the backs of the originals. Glossy photographs should be supplied unmounted and positive prints (not X-ray films or lantern slides), also unmounted, should be sent whenever possible. Drawings should be in a finished state suitable for reproduction. *Coloured illustrations* should be supplied where possible as paintings. When the originals are in the form of films the author should supply colour prints. As coloured illustrations are very expensive to reproduce, the author may on occasion be asked to make a contribution towards the cost.

REFERENCES.—The Harvard System should be followed.

In this system the name of the author and the date of the publication are given in the text; the list of authors quoted is put at the end of the article in alphabetical order. Each reference in the list should give, in order, the author's name, initials, the year of publication (in brackets), the full title of the paper,* the name of the journal, the volume (in heavy type arabic numerals), and the number of the first page of the paper. If the author cited has written more than one paper in the year, each should be distinguished by the letters a, b, and c, etc. For books, the place of publication should be stated and the publisher's name. The names of collaborating authors should be given in full on the first occasion, but in later citations the words "and others" should follow the first name.

Abbreviations for journals should be those adopted in the "WORLD LIST OF SCIENTIFIC PERIODICALS" (1952).

Only in papers in which many and frequent references have to be made should the items be numbered; the numbers may then be inserted in the text without interrupting it with a list of names.

* As an economy at the present time, the title of the paper may be omitted.

Lignocaine?

SPECIFY **XYLOTOX**

trade mark — brand

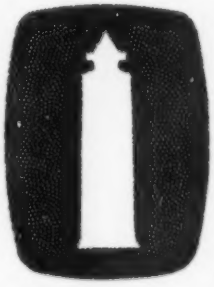
LIGNOCAINE Local Anaesthetics

RAPID • DEEP • CERTAIN • LASTING • SAFE

XYLOTOX Solutions

For major and minor surgery.
½%, 1% and 2% solutions, plain or with adrenaline, in 20, 50, 250 and 500 ml. bottles.

For surface anaesthesia of the mucosa.
4% solution, plain or with adrenaline, in 25 ml. bottles.



XYLOTOX Jelly

For effective urethral and vaginal anaesthesia.

For surgery use:-
15G. and 30G. tubes with applicators.

For instrument lubrication:-
Boxes 12 x 1.5G. tubes.

XYLOTOX Pastes

For truly efficient surface anaesthesia of the mucosa.

XYLOTOX-NORMAL (without amethocaine).

XYLOTOX-EXTRA (with amethocaine).

½-oz. tubes.

XYLOTOX Oral

For quick, simple surface anaesthesia of the upper digestive tract.

A viscous, pleasantly-flavoured product.

200 ml. bottles.

PHARMACEUTICAL MANUFACTURING COMPANY

The Local Anaesthetic Specialists

EPSOM · SURREY

A division of **WILLOWS FRANCIS LIMITED · EPSOM AND LONDON**

The operative word...

DEXTRAVEN

Trade Mark

A case for transfusion? Then the operative word is Dextraven—and Dextraven *first*.

Dextraven maintains the blood volume until normal physiological mechanisms make appropriate compensation. A safe colloid solution, Dextraven can be used *at once* in the prevention of shock, or to treat established shock. If more than two bottles are required in treating hypovolaemia due to blood loss, the patient should be given red cells.

WHY DEXTRAVEN?

. . . rather than BLOOD

Dextraven requires no cross-matching, can be stored for up to five years, and is perfectly sterile and non-toxic. Blood is indicated only where there is a definite need for an exogenous supply of red cells. Blood is saved for the occasions when only blood will suffice.

. . . rather than SALINE

Dextraven is a true blood volume restorer: some 60-70 per cent remains in the circulation for the first critical 24 hours.

. . . rather than PLASMA

Dextraven restores and maintains blood volume with equal effectiveness but without the definite risks of transmitting viral hepatitis, inducing antibody formation, and causing potassium overload.

Safe, quick to use, always at hand — DEXTRAVEN — first in every case

BENGER

BENGER LABORATORIES LIMITED · HOLMES CHAPEL · CHESHIRE · ENGLAND

destroy viable tumor cells during resection of the colon for carcinoma

with

CLORPACTIN® XCB

REFERENCES:

GLIEDMAN, M., GRANT, R., ROGERS, C., and KARLSON, K. E.: Clorpactin, A Surgical Adjunct; Tumorcidal and Antimicrobial Properties, "Surgical Forum" of the American College of Surgeons, Vol. VIII, 1958.

SOUTHWICK, HARRY W., and COLE, WARREN H.: Prophylactic and Adjuvant Measures in the Treatment of Carcinoma of the Colon; N. Y. State Jour. of Med., P. 86-103, Vol. 59, No. 1, Jan. 1, 1959.

BACON, HARRY E., and BERKLEY, J. L.: Refinements in Prevention of Recurrent Carcinoma Prior to and During Resection of the Colon and Rectum; Preliminary Report; J. of the Int'l. College of Surgeons, Vol. 30, No. 5, Nov. 1958.

SHIELD CHEMICAL LTD.

17 Jutland Rd., Toronto, Canada

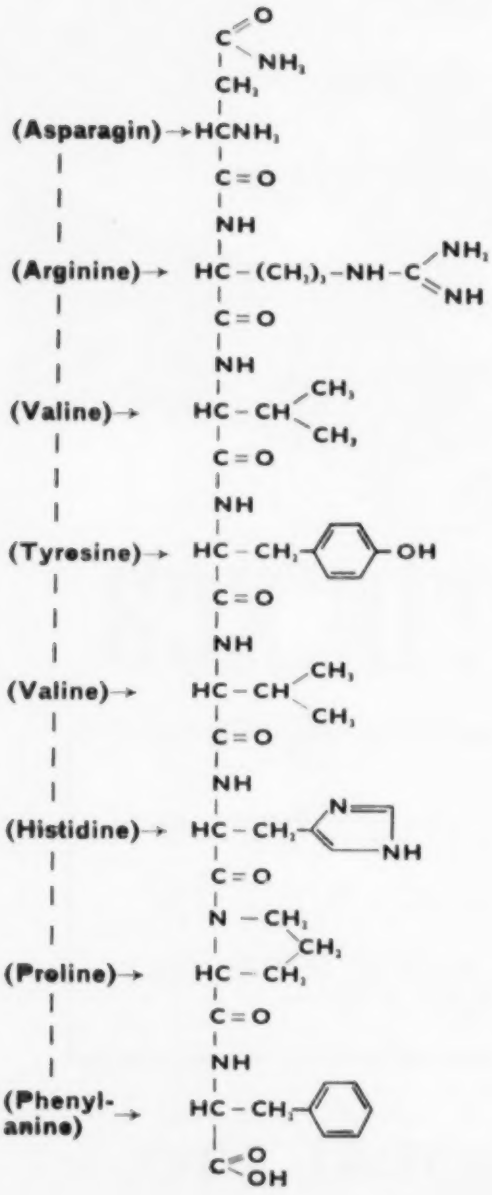
Exclusive licensee for Canada of the GUARDIAN CHEMICAL CORPORATION, U.S.A.

C I B A

New pressor agent

Hypertensin CIBA

for the treatment of shock and collapse



As a result of CIBA research, it is now possible to make this remarkable substance available. Hypertensin CIBA is about ten times more potent than noradrenaline.

Please write for 16-page booklet giving full details.

15/60

First Choice!

Matburn electro-surgical apparatus has proved itself first choice in hundreds of hospitals throughout Great Britain and overseas. This is because it is really safe, reliable and efficient—providing the noiseless high performance so vital in ever widening spheres of surgery.

No other apparatus of its kind can match the entirely non-corrosive construction of the new Matburn Series III vacuum pump unit. This has been evolved and designed with only surgery in mind—with components of stainless steel, phosphor-bronze and modern die-cast alloys.

This apparatus offers you many features of current surgical importance. Please write for literature which contains the fullest information.

MATBURN LIMITED, 20-24 EMERALD STREET, LONDON, W.C.1

Telephone: CHANCERY 9345 (3 lines) Telegrams: MEDICOLAB LONDON

Matburn

Fitting tribute

Craftsman-made VESSA artificial legs are designed and built to individual measurements from only the finest materials. Joints and components are manufactured to meet Ministry of Health requirements.

The real test of an artificial leg is, however, in the fitting, and the thousands of amputees who wear VESSA legs with absolute comfort are a tribute to our pre-eminence in this field. VESSA have also been responsible for many prosthetic design developments, particularly the development of the metal suction socket which eliminates the need for the conventional pelvic band and swivel joint attachment.

A comprehensive refit and repair service is available, and very speedy attention is given to this work.

Please write for complete details of models designed for Above-knee, Below-knee, Through-hip, Syme's operation, and for growing children.

Finished socke: for a VESSA artificial leg. Sockets are hand-beaten from sheet Alclad, fitted, rimmed and then assembled with rest of leg.

VESSA LIMITED
A member of the Vokes Group
Artificial legs and Orthopædic appliances

VESSA LIMITED

Works: PAPER MILL LANE, ALTON, HANTS.

Registered Office: Henley Park, Guildford, Surrey. Tel: Guildford 62861
London Fitting Rooms: Queen Mary's Hospital, Roehampton.

A member of the VOKES Group.

VE 30

NOW
IN
CHROMIC
STERILISED SURGICAL SUTURE (CATGUT) B.P.
(NON-BOILABLE) 5 FT.
ETHICON
LICENCE T.S.(M)4
FS 114
JUST
TEAR
OPEN!
* Trade Mark of Ethicon Ltd Edinburgh, 11

SERVING THE NEEDS OF THE HOSPITAL

Restful COLOUR FOR THE EYES OF SURGEONS AND NURSES . . .

The glare of ordinary white materials used in the theatre imposes severe strain on the eyes of Surgeons and Nurses. Stethos green and blue operating materials have met with universal approval. They are fast dyed and withstand constant steam sterilisation. J. H. Bounds Ltd. will be pleased to send patterns and prices of Stethos operating gowns, caps, sheets, towels, and all other operating equipment in colours or in white.

J. H. BOUNDS
LIMITED
STETHOS HOUSE
68 SACKVILLE STREET
MANCHESTER 1
TELEPHONES: CENTRAL 7331-4 · 4 LINES
TELEGRAMS: TENDER MANCHESTER

SPECIALISED CONSULTANCY SERVICE

J. H. Bounds Ltd. also offer an efficiently planned textile and Nurses uniform service to Regional Hospital Boards and Management Committees. No problem is too great or small and no region too remote for J. H. Bounds Ltd. to send their consultant specialists.

Davis & Geck

REGD.

SURGILAR

NEEDLE SUTURES

Heat Sterilized Gut in Plastic Envelopes with Atraumatic Needles

Now you can have needle sutures straight from their snip-open sterile envelope — undamaged, unkinked, far more flexible and with **perfectly sharp needle point and cutting edges.**

D & G needle sutures are made in shapes and sizes for most surgical procedures. Full details of range, sizes, and prices are available on application.

PRICE still 30s. 10d. per dozen.

SURGILAR envelopes are packed in space-saving, wide-necked jars for easy and quick removal and ready for immediate use — 1 doz. envelopes, per jar.

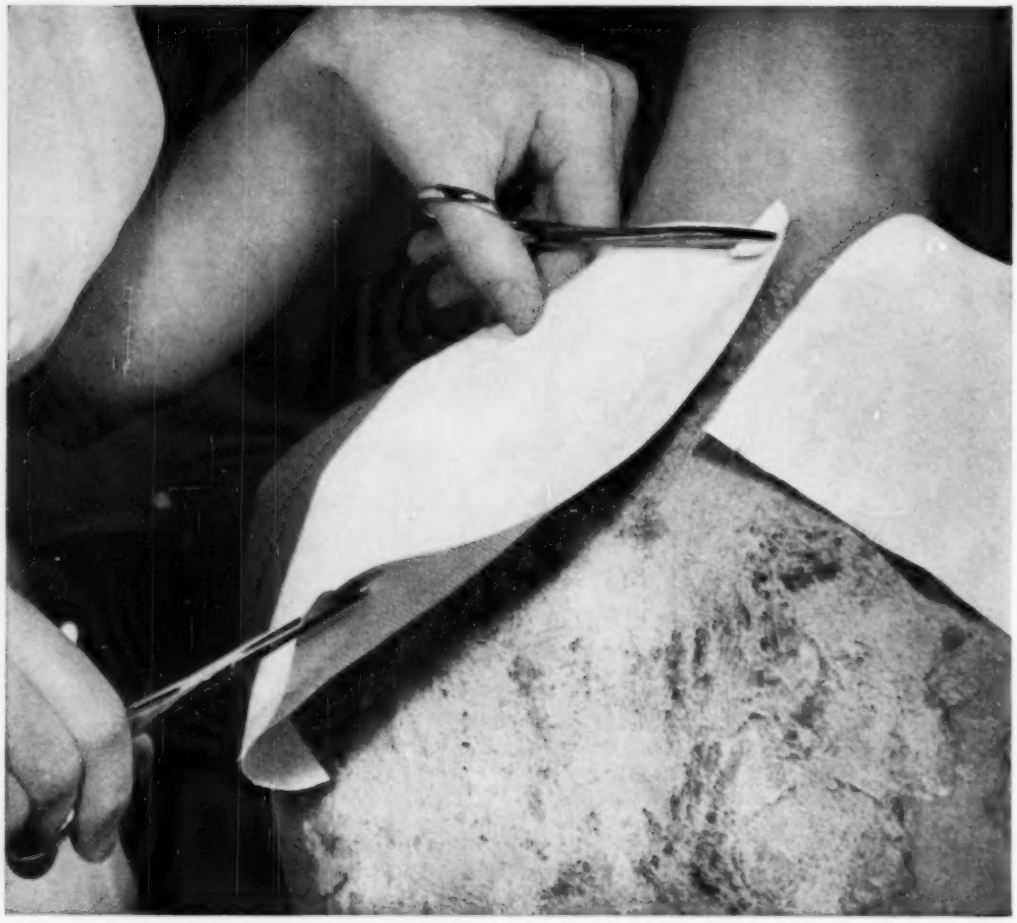
* Sterile plastic pack eliminates large glass tubes previously necessary to accommodate intestinal and general closure needles.
* Flattened area on body of needle prevents turning of curved and half circle needles in needle holder.
* Non-irritant jar solution ensures complete safety.

Sole Distributors in United Kingdom

Chas. F. Thackray LTD LEEDS & LONDON

Head Office: **THE OLD MEDICAL SCHOOL, PARK STREET, LEEDS 1**
Tel. 20085 (5 lines). Cables: "Aseptic, Leeds 1."
London Office: 38 Welbeck Street, London, W.1. Tel. WELbeck 8152/3.
Also at Johannesburg, Cape Town and Durban

MADE IN UNITED KINGDOM BY CYANAMID OF GREAT BRITAIN LTD.



Cestra

NON-ADHERENT

Wound dressing

A double-layer fabric constituting a dressing material which complies with all that can be required of a wound dressing; does not set up any kind of irritation in the wound; is permeable to air, and highly absorbent. The close, smooth weaving of the fabric prevents the granulations from growing into the dressing, as happens in the case of coarse-meshed fabrics such as gauze. The natural wound-healing process is not disturbed and the dressing can be removed easily and painlessly without damage to the wound.

Full details and samples supplied on request

ROBINSON & SONS LTD · WHEAT BRIDGE MILLS · CHESTERFIELD

PLEASE MENTION THIS JOURNAL WHEN WRITING.

a powerful weapon to combat

SHOCK

A powerful vasopressor agent that can be administered *intravenously, intramuscularly* or *subcutaneously*. The vasopressor effect is smooth and sustained, repeated injections give repeated responses, and secondary fall in blood pressure does not occur. Cardiac arrhythmias and other side-effects usually associated with vasopressor agents need not be expected.

Offering a choice of routes:
Intravenous, Intramuscular, or Subcutaneous

Injection **ARAMINE**

Trade Mark

Metaraminol Bitartrate

How supplied: In 1 ml. ampoules and 10 ml. vials (10 mg. per ml.)
Literature available on request.

MERCK SHARP & DOHME LIMITED, HODDESDON, HERTS

NEW

High Efficiency
Pressure Packed

Polybactrin

Antibiotic Powder Spray

This new presentation of POLYBACTRIN is the result of intensive research into the mechanics of pressure packing antibiotics in powder form. While the formula and potency of POLYBACTRIN remain unchanged, radical modification of the valve mechanism and design of the unit provides the following advantages:—

NEW **positive directional, wide-angle spray gives wider coverage of the area under treatment.**

NEW **all metal container provides additional safety**

NEW **special valve eliminates impacting of powder and clogging of nozzle**

The use of Polybactrin during surgical procedures is a positive method of inhibiting any wound pathogens which may become implanted in the tissues.

INDICATIONS: Prophylactic—treatment of Burns—general surgery—Gynaecological operations—orthopaedic surgery etc.

FORMULA: Powder content 1.5g.

Each gramme contains:

Neomycin Sulphate	**500 mg.**
Polymyxin B Sulphate	**100,000 units**
Zinc Bacitracin	**25,000 units**

Pressurised with inert chlorofluorohydrocarbon propellants.

NET CONTENTS 110g.

CALMIC LIMITED

CREWE, CHESHIRE Tel: CREWE 3251

London: 2 Mansfield Street, W.1.
Tel: LANgham 8038

A PRODUCT OF BRITISH RESEARCH

BAXTER

The NEW Medical

Cerebrospinal Decompressant

UREVERT

Regd. Trade Mark

For Intracranial Emergencies

The use of **UREVERT**
has
Improved many prognoses
Reduced severe headache
Enlarged the operative field
Minimized brain damage
Shortened surgical
intervention

in these conditions

Brain Tumors
Acute Glaucoma
Head injuries
Cerebral Oedema
C.N.S. Infection
Hypophysectomy
Trigeminal rhizotomy

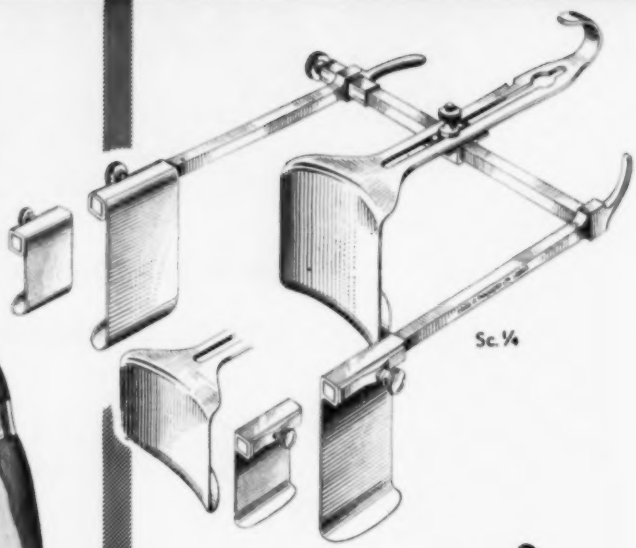
Full medical information is available on this product from

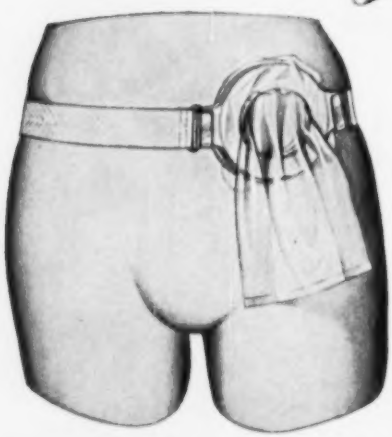
Baxter Laboratories Ltd.
26, Great Tower Street
London, E.C.3.

Selection of instruments from our new catalogue . . . .

GOLIGHER'S modified
BERKELEY'S RETRACTOR
for lower abdomen.

Cat. No. AD 4688. Used for rectal excision. Detachable blades of two depths for varying degrees of obesity.





SCHACHT COLOSTOMY APPLIANCE

Patent applied for.

Cat. No. AD 4722

A secure, comfortable, hygienic and inconspicuous appliance giving—positive seal with no danger of leakage, protection from chafing and irritation.

THE *DISPOSABLE POLYTHENE BAG* IS EASILY AND QUICKLY CHANGED.

Illustrated leaflet on request.

GOLIGHER'S
RECTAL SPECULUM

Cat. No. AD 4716

Designed primarily for internal sphincterotomy, this speculum affords ideal exposure for other rectal operations, such as removal of hypertrophied anal papillae under local anaesthesia, diathermy of benign tumours of the extreme lower end of the rectum and submucosal haemorrhoidectomy. The third blade holds the mucosa of the anterior anal wall out of the operation field.

Vide: "*The Lancet*", April 19th, 1958, pages 831-832.

"ADDENDA OF NEW INSTRUMENTS" supplementing our complete instrument catalogue now available.

Chas. F. Thackray LTD
LEEDS & LONDON

Head Office:
THE OLD MEDICAL SCHOOL
PARK STREET, LEEDS, 1. Tel: 20085 (5 lines)
Works: St. Anthony's Road, Leeds 11.
London Office:
38 *Welbeck Street, London W.1.*
Tel: WELbeck 8152/3
Also at Johannesburg, Cape Town and Durban.

Manufacturers of Surgical Instruments, Hospital Furniture and Sterilizing Equipment.

NOW! 3 drugs of value for the Surgeon

1 2 3

CLORPACTIN® XCB

- to destroy viable tumor cells in cancer surgery in preventing local recurrences by seeding

RENACIDIN®

- to prevent plugging by calcium deposits of catheters placed in the urinary tract

CLORPACTIN® WCS-90

- to treat chronic infections of an antibiotic nature such as infected wounds, empyemas and sinus tracts
- to reduce the number of postoperative infections resulting from both clean and contaminated wounds

1

BACON, HARRY E., and BERKLEY, J. L.: Refinements in Prevention of Recurrent Carcinoma Prior and During Resection of the Colon and Rectum; Preliminary Report; Jour. of Int'l. College of Surgeons, Vol. 30, No. 5, Nov. 1958.

SOUTHWICK, HARRY W. and COLE, WARREN H.: Prophylactic and Adjuvant Measures in the Treatment and Carcinoma of the Colon; N. Y. State Jour. of Med. P. 86-103, Vol. 59 No. 1, Jan. 1, 1959.

2

MULVANEY, WILLIAM P.: "A New Solvent for Certain Urinary Calcifications", Jour. of Urology, Oct. 1959.

3

GLIEDMAN, M. L., GRANT, R. N., VESTAL, B. L. and KARLSON, K. E.: Impromptu Bowel Cleansing and Sterilization; Surgery 43: Pg. 282-287, Feb. 1958.

DuVAL, MERLIN K. and HOWARD, FRANK H.: "The Influence of Clorpactin WCS-90 on the Bacterial Complications of Surgery", Surgery, Pg. 210-216, Feb. 1960.

Literature and references on the above are available on request.

SHIELD CHEMICAL LTD.

17 Jutland Rd., Toronto, Canada

Exclusive licensee for Canada of the GUARDIAN CHEMICAL CORPORATION, U.S.A.

London Hospital Catgut

is a British surgical catgut, sterilised by chemical methods instead of by heat.

The process is unique—and renders L.H.C. more flexible and more elastic.

Absorption factors are reliable. Tensile strength exceeds B.P. Standards,

so that the finest gauge suited to the operation can be used with safety.

This means less scar tissue and quicker healing.

always use London Hospital Catgut

the more F·L·E·X·I·B·L·E suture

Now packed in the non-splintering 'Spot' Tubes

THE
BRITISH JOURNAL OF SURGERY

VOL. XLVII MAY, 1960 No. 206

SENSORY NERVE-ENDINGS AND SENSATION IN THE ANAL REGION OF MAN

BY H. L. DUTHIE AND F. W. GAIRNS
DEPARTMENTS OF SURGERY AND PHYSIOLOGY, UNIVERSITY OF GLASGOW

THE anal region in man (circumanal skin and anal canal) is extremely sensitive, yet a search of the literature reveals that little work, histological or experimental, has been done on its sensory innervation. The histological investigations of Ottaviani (1940) were mainly on small animals and mostly concerned with the rectum. However, he did note that there were nerve-plexuses made up of thick and thin fibres beneath the columnar epithelium of the rectal columns. No mention was made of organized sensory nerve-endings. In work on human adult and embryonic material Seto (1940), using his own modification of the Bielschowsky-Gros method, described intra-epithelial free endings in the anal canal and illustrated them by means of diagrams. His study was concerned particularly with the nerves of the epithelium and no organized endings were described. Using a Cajal silver technique Sotelo (1954) demonstrated nerve-fibres at the anal canal ducts in human fœtuses, although no organized endings were described. The nerve-fibres apparently supplied both endings in the skin and other endings in the glandular epithelial surface. Using Seto's method, Izumi (1955), one of his pupils, described organized endings in the anal region of man and illustrated them by drawings. He noted large and small end-formations which he believed to be two types of genital bodies. He also described and illustrated branching nerve-fibres which were thought to be simple or complex terminations according to the number of subdivisions involved in the termination. In addition, in the subcutaneous fat he found Pacinian corpuscles which he thought were rather smaller than those usually found elsewhere. He emphasized that the nerves and endings diminished markedly in number in the zona columnaris. In a study on human sigmoid colon and rectum Wang Wei Fan (1955) found myelinated fibres and branching non-myelinated fibres to which he attributed a sensory function. No end-formations were shown in connexion with these fibres. However, he noted some tangled glomerular endings lying close to the basal membrane of the epidermis at the mucocutaneous junction. These he considered to resemble genital corpuscles. Two types of ending have been described by Kantner (1957) in connexion with a deep and superficial network of fibres in the submucosa at the mucocutaneous junction. He remarked on the presence of occasional Pacinian corpuscles near the anal sphincters. The rectum he found to lack organized endings and networks and to have submucosal nerve-fibres the branches of which were in close relationship to blood-vessels near the epithelium.

The present study was undertaken to investigate the sensory nerve-endings in the perianal skin, the anal canal, and the adjoining rectal mucosa. A preliminary report of the findings has already been published (Duthie and Gairns, 1958).

MATERIAL AND METHODS

Histological.—Material for the investigation was obtained from ten human beings whose ages ranged from 34 to 70 years. Three of the specimens were from early autopsies and the remainder were obtained at operation. Histological examination confirmed the essential normality of the tissues in our selected pieces. A continuous longitudinal strip containing perianal skin, anal canal, and rectum was removed; this was pinned out on cork board and placed in 12 per cent neutral formalin for a minimum period of four days. Since the entire strip could not be sectioned as a whole, numbered pieces in sequence, each about 2 cm. in length, were taken. In the junctional areas the pieces were cut so that they extended over the junction between skin and anal canal or between anal canal and rectum. Since the staining procedures for both ends of each piece were identical, the results obtained in the two adjacent regions over which the piece extended were truly comparable.

The limits of the perianal skin examined in any of our cases were 10 cm. from the anal margin in an anteroposterior axis and 5 cm. in a lateral direction.

The selected pieces were then washed in running water for a few minutes and sections 15–20 microns thick cut on the freezing microtome. The sections were then impregnated by a modified Bielschowsky-Gros silver diamine ion method (Garven and Gairns, 1952) and when selectively impregnated were mounted in a thick lævulose syrup which was excellent for high-power microscopy. The advantage of this mounting medium was that the sections could be mounted directly from the last washing of distilled water, so avoiding the shrinkage that occurs

in the usual routine dehydration and clearing processes. Furthermore, the time and labour saved by using the lævulose was considerable.

In one case hyaluronidase was injected into the specimen before it was fixed in the neutral formalin. Apart from this the technique was identical.

In addition to the silver impregnation technique, parallel sections were prepared by the routine paraffin method and subsequently stained with hæmulum and eosin and by the Masson trichrome method.

Testing of Sensation.—Tests were made on 15 subjects, aged from 17 to 63 years, none of whom had any lesion in the anorectal region.

The methods used were those of normal clinical practice: control tests were carried out on the fingertips of each patient. To test for tactile sensibility a horse hair in a graduated holder (von Frey model) was used with 1·5 cm. of the hair exposed. Pain was investigated with a needle (Aly's algometer) which was inserted in the skin just short of drawing blood. Temperature stimuli were applied by means of a metal rod with a plate 8 × 2 mm. fitted at right angles so that the side of the anal canal could be tested. Cold stimuli were given at 4° C. and hot at 35° C. The plate was held in position for a maximum of 5 sec.

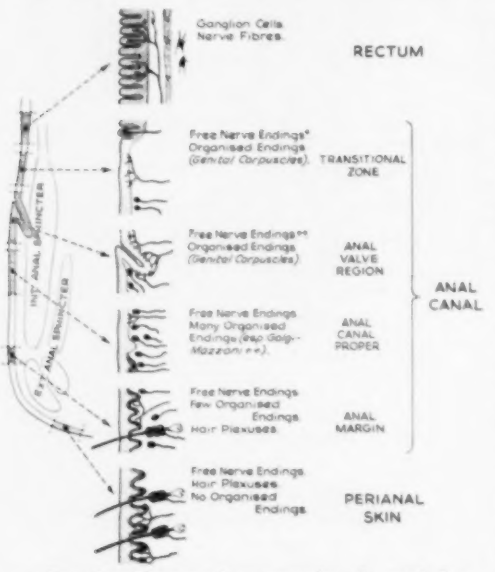


FIG. 581.—Diagrammatic representation of general distribution of the types of sensory nerve-endings in the anal region.

These stimuli were applied to the perianal skin up to a maximum of 10 cm. from the anal margin and the anal canal and adjacent rectal mucosa. In the anal canal appreciation of movement was tested by a cylinder 1·5 cm. in diameter, which was lubricated and inserted in the anal canal: also by applying a cylindrical rod 0·7 cm. in diameter along the full length of the canal, which was held open by a speculum, and then moving the rod, maintaining as far as possible an even contact with the epithelium.

The difficulties of testing the sensation in the anal canal and surrounding perianal skin can well be imagined. It is virtually impossible to achieve a smooth surface on which to map out any area to be investigated, so that any quantitative measurement must be very rough. Further, to be able to apply stimuli to the anal canal some type of speculum is required. This stimulates nerve-endings in both the mucosa and the anal sphincteric muscles so that there is a constant background of sensation while the test stimuli are being applied to the chosen area of the anal canal.

RESULTS

HISTOLOGICAL

There has been little agreement in the past about the general histology of the anal region, especially with regard to the changes in the epithelial surfaces. In order to clarify the presentation of the results of the study, some preliminary description must be made of this subject. The regions mentioned are shown in *Fig.* 581.

The perianal skin has a typical keratinized stratified squamous epithelium with heavy deposits of melanin in the basal layers. Both the keratinization and the melanin deposits lessen gradually craniad along the anal canal and are no longer present just craniad to the anal valves. The stratified squamous epithelium is continued over the surfaces of the anal valves and becomes stratified columnar at a variable depth in the anal crypts. Most difficulty has arisen from the fact that the transition from stratified squamous epithelium to the simple columnar epithelium of the rectal mucosa is by no means sharply defined. It may occur up to 1–1·5 cm. craniad to the anal valve and the level may vary around the circumference of the lumen in the same individual. In addition, this transition can take place abruptly or with the interpolation of an area of stratified columnar epithelium varying greatly in length. Above this level there is a frank intestinal mucosa with typical simple columnar epithelium and goblet cells. More detailed work on the histology of the anal canal has recently been published by Walls (1958), with a review of the literature.

The sensory nerve-endings found in this study will be described as they occur in: (1) The perianal skin; (2) The anal canal (the anal canal is taken to extend from the anorectal ring to the anus, as suggested by Walls (1958)); (3) The rectal mucosa. This description will follow the diagram in *Fig.* 581.

1. Perianal Skin.—The innervation of this area appears to be similar in pattern to that of the hairy skin found elsewhere on the body surface. Intraepithelial free endings are present though the finer details are frequently obscured by a heavy silver impregnation of the melanin in the basal layers of the epithelium.

Organized endings are absent, although a profuse innervation to the hair follicles is found (*Fig.* 582). This is supplied from thick myelinated nerve-fibres which, after repeated divisions into finer branches, form a cylindrical network around the sheath of the hair follicle. From these branches finer fibres pass

between the cells of the sheath to form neurofibrillar expansions (*Fig.* 583). This innervation seemed to be in no way different from that which we have observed in association with hair follicles elsewhere in the human hairy skin. No variation in this overall sensory pattern could be detected within the limits of the pieces examined.

2. Anal Canal.—The nervous structures of this part will be described as they occur in three regions from without inwards.

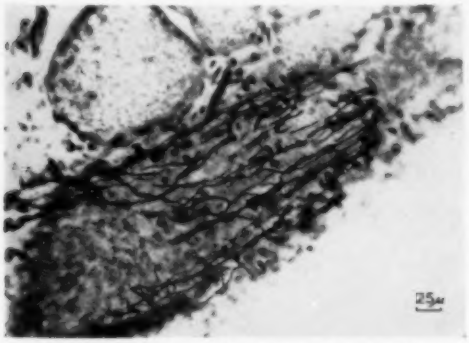


FIG. 582.—Photodiagram showing nerve-plexus on a hair follicle at the anal margin. Bielschowsky-Gros.

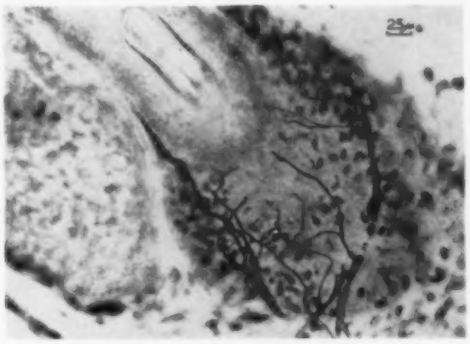


FIG. 583.—Photodiagram showing nerve-fibres ending in small disks and knobs amongst cells of the root-sheath of the hair follicle. Bielschowsky-Gros.

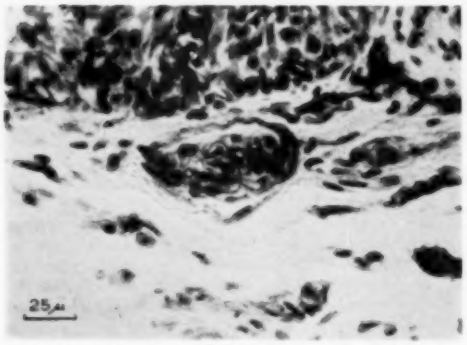


FIG. 584.—Photomicrograph showing encapsulated ending, in apposition to a hair follicle. Bielschowsky-Gros.

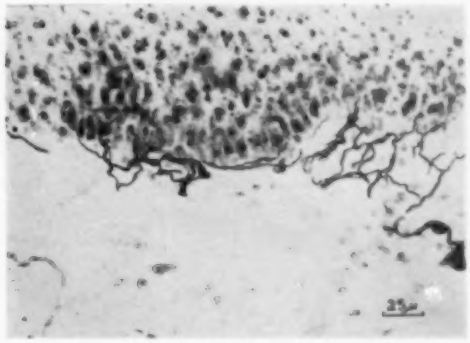


FIG. 585.—Photodiagram showing free nerve-endings terminating in small knobs in the basal layers of the epithelium. Bielschowsky-Gros.

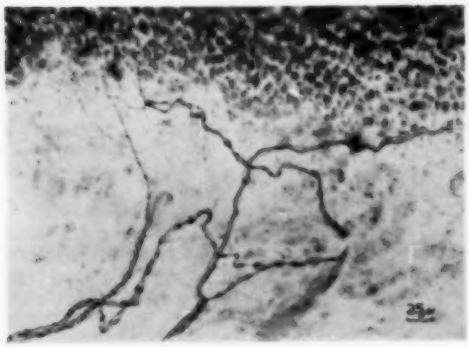


FIG. 586.—Photodiagram showing plexus of beaded fibres below the epithelium. Bielschowsky-Gros.

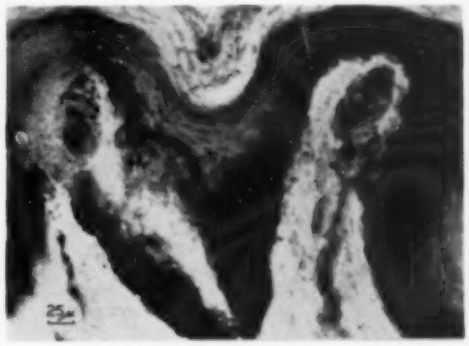


FIG. 587.—Photomicrograph showing two Meissner corpuscles in their typical position in the dermal papillæ. Bielschowsky-Gros.

a. The Anal Margin.—The skin here contains only occasional hair follicles and their innervation appears to be the same as for the follicles in the perianal skin. A feature of this area is the occurrence of

a few organized endings, indistinguishable from Krause end-bulbs. These end-bulbs often lie very close to, and may even touch, hair follicles (*Fig.* 584). The association of considerable numbers of margin. Some of the nerve-bundles pass towards the epithelium before the fibres separate and divide into fine branches to form free nerve-endings just below the epithelium. Other nerves send their

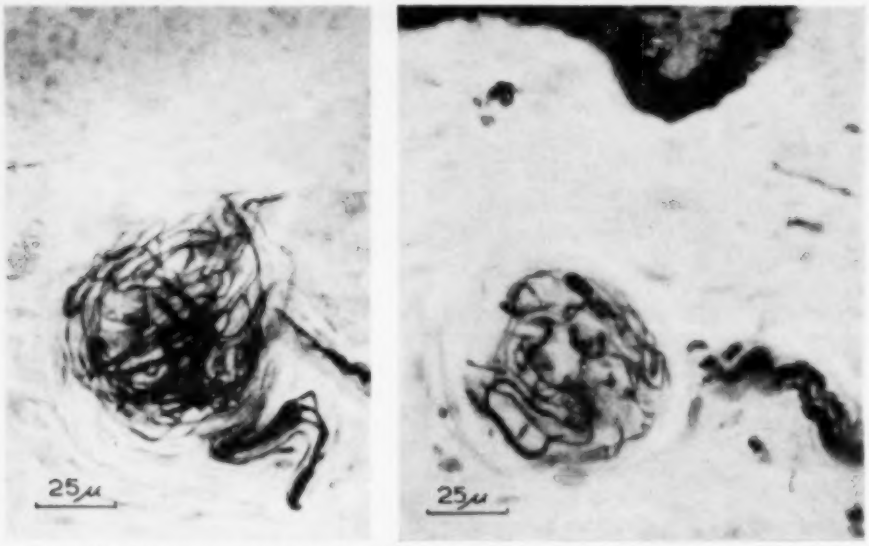


FIG. 588.—Photomicrograph showing two Krause corpuscles in their typical position below the epithelium. Bielschowsky-Gros.

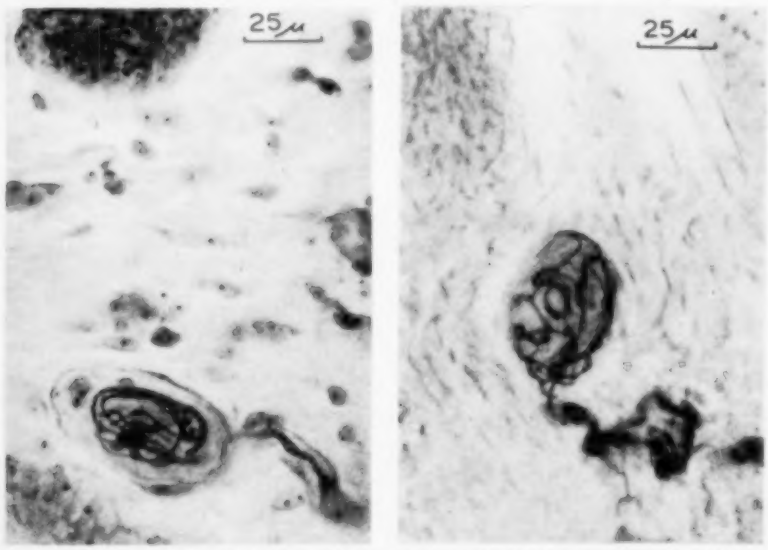


FIG. 589.—Photomicrograph of two Golgi-Mazzoni bodies. The one on the left shows its thick myelinated fibre and a well-marked capsule. The other ending shows more of the intrinsic nerve elements. Bielschowsky-Gros.

organized endings with hair follicles seems to distinguish this area from most other parts of the hairy skin.

b. The Anal Canal Proper.—The innervation of this region is notably richer than that of the anal branches into the actual epithelium, where they ramify amongst the basal cells and usually terminate in discrete end-knobs (*Fig.* 585). It has been noted that some of the non-myelinated fibres are beaded throughout their length (*Fig.* 586). They appear in

most cases to be associated with the blood-vessels of the papillæ, although at many sites a few could be observed to enter the avascular epithelium.

Numerous nerve-trunks containing non-myelinated and myelinated fibres of varying calibre are seen supplying a profusion of encapsulated and unencapsulated organized endings. As many as twenty of these endings can be found in one histological section 20μ thick and 2 cm. in length. Some of the endings are readily identified as Meissner corpuscles, Krause end-bulbs, Golgi-Mazzoni bodies, and genital corpuscles.

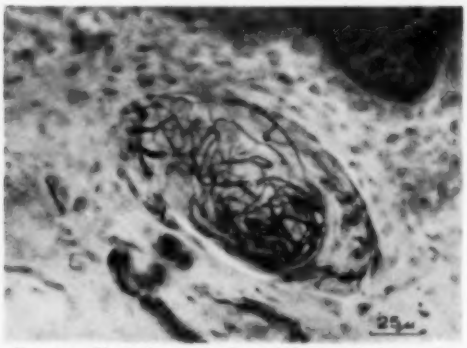


FIG. 590.—Photomicrograph of a genital corpuscle deep to the epithelium of the anal canal. Bielschowsky-Gros.

The Meissner corpuscle is relatively infrequent, but when present lies in its typical position in a dermal papilla close to the epithelial margin (*Fig.* 587). They appear to be less highly developed than those, for example, in the finger-tips. They may be supplied by several thick nerve-fibres. Fibres of much smaller diameter also are occasionally seen passing into these corpuscles. In this respect they resemble the Meissner corpuscle of the finger-tip (Cauna, 1956).

Krause end-bulbs vary somewhat in size and in the calibre of their intrinsic fibres (*Fig.* 588).

The Golgi-Mazzoni bodies are present in fairly large numbers (*Fig.* 589) and are certainly one of the features of this region. They usually lie deeper than the Meissner corpuscles or the Krause end-bulbs and characteristically have a prominent capsule; their internal axonic branches are few in number and relatively coarse. Rarely the long axis of the Golgi-Mazzoni ending is directed towards the epithelial surface; more usually it is parallel to this surface (*Fig.* 589).

The genital corpuscles are also present in large numbers and are the second main feature of this region (*Figs.* 590, 591). They are frequently present in clusters, are roughly spherical in shape, but are poorly encapsulated. The intrinsic branches of the supplying nerve-fibres are numerous, relatively thin in diameter, and very closely interwoven; not infrequently some of the branches pass outside the body of the corpuscle into the surrounding tissue (*Fig.* 592). They lie at varying depth in the dermis either close to the epithelium in a dermal papilla or at considerable depth below this.

No Ruffini corpuscles have been found in any of the areas studied.

Pacinian corpuscles can be seen, although they lie much deeper than all the other types mentioned. They appear to be more in the region of the muscle-bundles and are therefore in a separate category from those described above.

In addition to these named end-organs, there exist many other endings which do not readily fit into any of these categories. They are usually supplied by large-diameter nerve-fibres but do not exhibit any encapsulation of the ending. Some of them lie in indentations of the epithelium and are of a loosely coiled type (*Fig.* 593). A rather more complex coiled form is regularly found at the point of junction between the stratified squamous epithelium and the stratified columnar (*Fig.* 594). An example in the form of a whorl is shown in *Fig.* 595. In this instance some of the branches form discrete end-knobs. A very large mass of closely compressed intertwining nerve-fibres is often found completely filling the biggest dermal papillæ (*Fig.* 596), especially in the region of the anal valves and crypts. These are supplied by many thick myelinated fibres which exhibit prominent Schwann-cell nuclei. Two of these massive endings may be found in adjacent papillæ (*Fig.* 596). Some of the component nerve-fibres show expansions of their neurofibrillar elements.

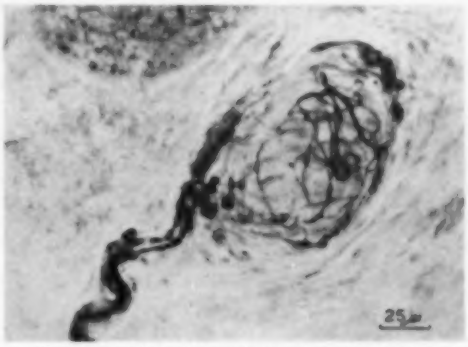


FIG. 591.—Photomicrograph showing two myelinated nerve-fibres entering a genital corpuscle. Note deeply stained Schwann-cell nuclei. Bielschowsky-Gros.

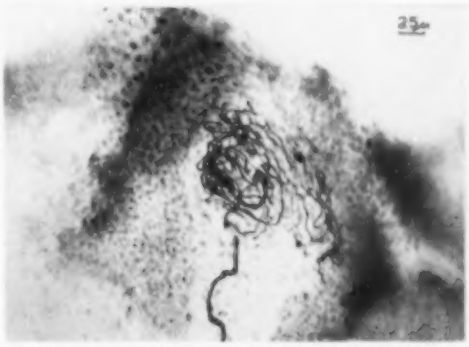


FIG. 592.—Photodiagram showing a genital corpuscle in which some of the branches pass out from the main body of the corpuscle.

Lying deeper than these is another type of ending in the form of a simple skein (*Fig.* 597).

c. Region of Crypts and Valves.—The endings found in this region are similar to those described under "The Anal Canal Proper", though the proportion of the various types is altered. In this region the free nerve-endings are extremely numerous, indeed in all our studies of the different areas of the skin surface we have not seen such a profusion of this kind of ending. The organized endings are in different proportions, e.g., the Golgi-Mazzoni bodies are less numerous whilst the genital corpuscles are increased. These latter are present not only adjacent to the epithelial surface, but also throughout the length of the crypts. The massive type of ending depicted in *Fig.* 596 is found here more often than in any other region.

3. Rectal Mucosa.—The large numbers of free nerve-endings and organized endings cease abruptly with the change to rectal mucosa, and in all the sections taken from the various cases only one organized ending has been found (*Fig.* 598). This ending was near to the transitional zone but clearly lay in one of the folds of simple columnar epithelium in the rectal mucosa proper. Fragments of the supplying nerves to this ending were followed through consecutive sections and it appeared that these came from the same leash of nerves as supplied some of the endings in the stratified squamous epithelium. It should be remembered that this area was stained in continuity with the anal canal, where numerous endings are to be found. In addition to this solitary ending in the rectal mucosa, many nerve-trunks, either myelinated or non-myelinated, are present. Many of the non-myelinated fibres are beaded and they can be seen running towards the epithelium. In no case were definite intra-epithelial endings seen to arise from this type of nerve-fibre. Other types of

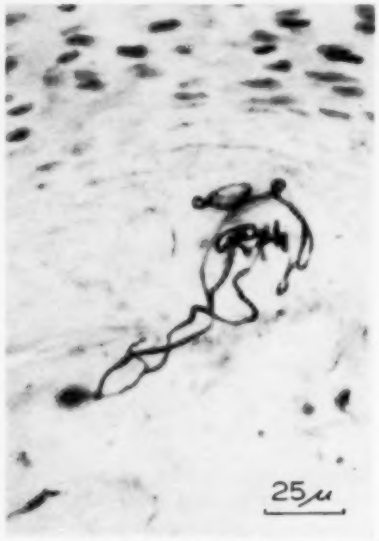


FIG. 593.—Photomicrograph of two of the loosely coiled type of ending closely associated with the epithelium. Bielschowsky-Gros.

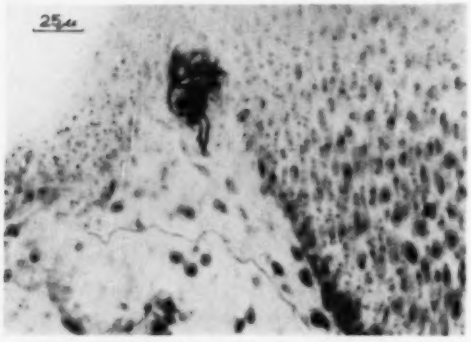


FIG. 594.—Photomicrograph showing a small loosely coiled ending at the junction between stratified squamous and stratified columnar epithelium. Bielschowsky-Gros.

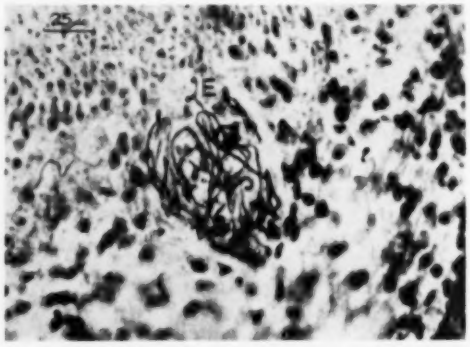


FIG. 595.—Photomicrograph of an unencapsulated ending in the form of a whorl. Note end formation at E. Bielschowsky-Gros.

nerve-fibre can be seen in close association with small blood-vessels of the submucosa where the nerves form fine plexuses. The ganglion cells and processes of Meissner's plexus are easily identified lying in their usual site in the submucosa.

EXPERIMENTAL

These results are illustrated in *Fig.* 599.

Perianal Skin and Anal Canal.—The results were similar in all subjects.

Touch (15 subjects).—All stimuli were appreciated in the anal canal and on the surrounding perianal skin. The cranial limit of the response was 0·25–0·75 cm. craniad to the anal valves and varied from subject to subject, and around the circumference in the one individual. There was a heightened sensitivity

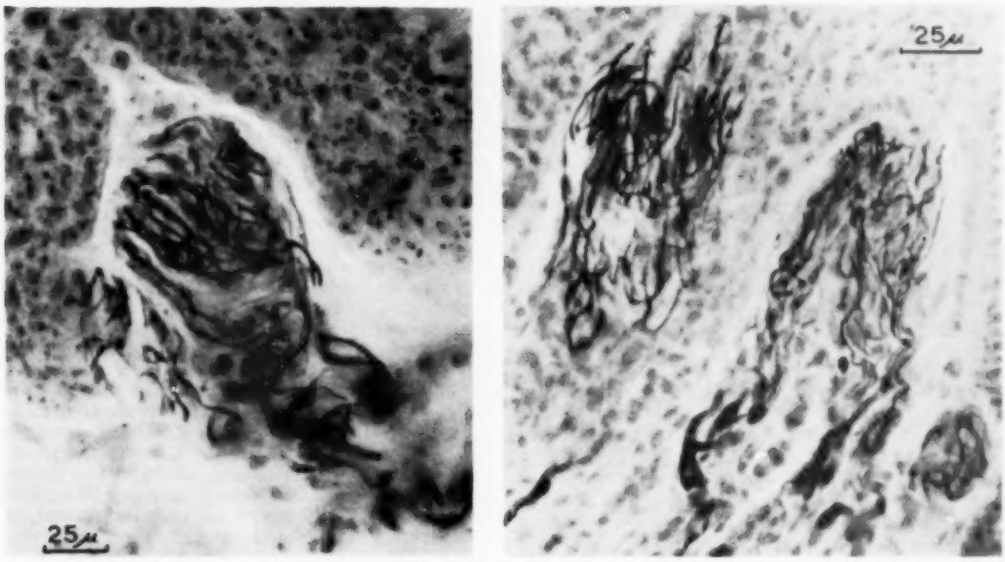


FIG. 596.—Photomicrograph showing three examples of the massive type of ending. Note the two endings on the right are in adjacent papillæ. Bielschowsky-Gros.

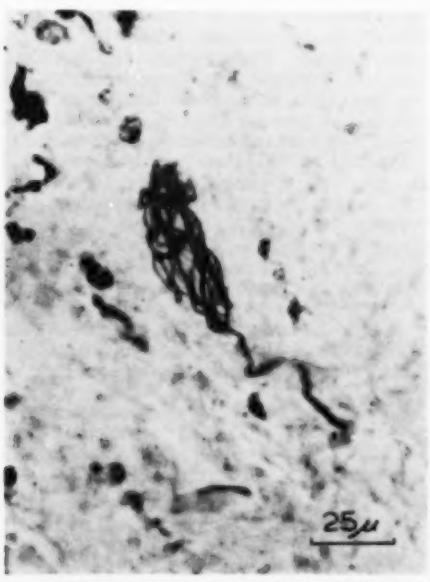


FIG. 597.—Photomicrograph of an unencapsulated ending in the form of an elongated skein. Bielschowsky-Gros.

FIG. 598.—Photomicrograph showing the only sensory ending found in the rectal mucosa. Bielschowsky-Gros.

to touch in the anal canal but the localization was poor. The level of the stimulus could be gauged roughly by the subject, but the site in relation to the circumference of the canal could not be distinguished accurately.

Pain (12 subjects).—All pin-pricks were felt and those in the anal canal were felt more vividly than

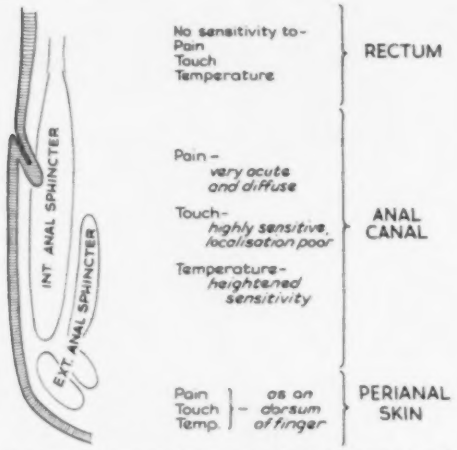


FIG. 593.—Diagrammatic representation of the distribution of appreciation of different sensory modalities.

those on the perianal skin. This was most noticeable in the neighbourhood of the anal valves. The cranial limit of this sensation was also craniad to the anal valves about 0·5–1·5 cm. and showed the same variations as noted with touch. Pain was usually felt up to 0·5 cm. craniad to touch. As already noted, the pain was more marked in the anal canal but was less well localized so that the subject could estimate approximately at what level in the anal canal the stimulus was given, but its whereabouts around the circumference was indefinite.

Cold and Heat (7 subjects).—These stimuli were appreciated more readily in the anal canal than on the surrounding skin in all subjects tested. Precise localization of the cranial limit of this sensation was not achieved in view of the size of the testing instrument, but both cold and heat could be felt just craniad to the anal valves.

Movement in the Anal Canal (4 subjects).—Using either method described above, a slight longitudinal or rotatory movement could be detected by the subject.

Rectal Mucosa.—None of the stimuli were appreciated in the rectal mucosa craniad to the limits defined in the results above.

DISCUSSION

The outstanding feature of the innervation of the anal canal is the profusion of both free and organized nerve-endings, especially in the vicinity of the anal valves. The organized endings may or may not have a capsule: they are usually supplied by one or more branches of myelinated fibres of large diameter. While many of these encapsulated endings conform to the descriptions of the classical eponymous forms, there are others which do not fit into these categories. These others vary considerably in size, in structure, and in position, and appear to be examples of several forms and not just variations of the one form. Despite the complex arrangement of the nerve-endings throughout the region, the pattern of the distribution is very similar in all the cases studied. Of special interest is the presence of peritrichial endings and of organized sensory endings, usually of the Krause type, in close apposition. This is seen at the anal margin and may be due to an overlap between the innervation of the perianal skin, where the peritrichial endings are found, and the innervation of the anal canal, where many organized endings are present. So far as we know, no other area of hairy skin has as many encapsulated endings. Thus our findings run counter to the belief that where peritrichial endings are present organized endings are almost entirely absent.

Early workers could find no organized sensory nerve-endings in hairy skin. Using the Bielschowsky silver method and also methylene blue, Pendelton (1928) could not identify any Golgi-Mazzoni, Ruffini, or Krause endings in hairy skin, a finding which Gilbert (1929) confirmed using hæmatoxylin and eosin in specimens taken from many areas of the body. No organized sensory nerve-endings were found by Sinclair, Weddell, and Zander (1952) in the areas they examined of hairy skin from the human ear. Using tried and trusted histological methods, they demonstrated only peritrichial and free nerve-endings. This they believe to be true for all areas of hairy skin, as indeed it may be, except at this site in the perianal skin. These authors found that the skin on the pinna was as sensitive to touch, to pain, to warmth, and to cold as the glabrous skin of the hand, a finding which caused no little perturbation in the minds of those who would dearly like to identify one modality of sensation with a single type of nerve-ending. Again, when Hagen, Knocke, Sinclair, and Weddell (1953) examined 10 sq. cm. of human abdominal skin, where hairs were present, they found not one unequivocal organized ending. A similar result was obtained when they examined the hairy skin of the lip and of the dorsum of the finger.

The presence of Meissner's corpuscles in the skin of the anal canal is, we think, of no special significance; one expects to find them in any area of glabrous skin. In this instance they are not so elaborate in structure as those found in the papillæ in the skin of the finger-tip. Some of the unclassified endings described above are to be found in the same positions in the dermal papillæ as Meissner corpuscles usually occupy, and may serve the same function.

The Krause end-bulbs are probably as numerous, if not more numerous, than any other type of organized ending in the epithelium of the anal canal. They usually lie fairly deep in the dermis, though one occasionally lies in a little indentation in the epithelium. They occur consistently in the glabrous skin at some sites, usually deep in the epidermis and only rarely close to, or actually in, a papilla. In the anal canal they may be responsible for the acute sensitivity to cold: it may be significant that the

gum and palate, also most sensitive to cold, are profusely endowed with Krause end-bulbs (Strughold, 1925; Gairns and Aitchison, 1950; Gairns, 1955).

Nowhere else in the skin have we seen Golgi-Mazzoni bodies in such numbers. They have characteristically only a few lamellæ and are thus easily distinguished from the much larger Pacinian corpuscle with its numerous lamellæ. The Golgi-Mazzoni corpuscles lie more superficial than do the Pacinian corpuscles, and may thus respond to changes in tension or pressure in the more superficial tissues. Rather unexpectedly, few Pacinian corpuscles are to be seen in the tissues deep to the epithelium of the anal canal. Their functions may be taken over by the Golgi-Mazzoni endings.

No Ruffini corpuscles were found in the tissues from any part of the anal region; this is in keeping with our findings in skin from other areas of the body.

The identification of undoubted genital corpuscles in considerable numbers close below the epithelium of the anal canal suggests that friction is to be expected as a stimulus in the region. They may indeed act as receptors for a reflex in the second stage of defæcation. Movement in the anal canal reflexly causes contraction of the colon and rectum and leads to the relaxation of the internal and external anal sphincters (Garry, 1933; Bishop, Garry, Roberts, and Todd, 1956).

So far the discussion has considered only the named varieties of organized ending: there is, however, a significant number of other endings, for example, loosely-coiled forms, whorls, and skeins. These, too, must have some place in the sensitivity of the anal region since in number they at least equal the eponymous forms. The size and complexity of the massive endings observed in some dermal papillæ near the anal valves are unique in our experience of sensory nerve-endings in the skin. The presence of such numbers of additional types of endings must surely have some significance. To assign to any one of these endings any precise modality would be entirely speculative and without profit: more work is required before an opinion can be expressed.

The abundant nerve-supply to the region of the anal valves correlates well with the extreme sensitivity of the part: an anal fissure is exquisitely painful and an incautious injection below the mucocutaneous junction causes much distress. Our illustrations show clearly endings which are generally assumed to be able to give rise, when stimulated, to the sense of pain (free intra-epithelial), touch (corpuscles of Meissner), cold (Krause end-bulbs), and pressure (corpuscles of Pacini and Golgi-Mazzoni). These are present in an area which is usually protected from stimuli except during the passage of fæces.

The allocation of specific sensory modalities to the different morphological types of organized endings in the skin is at present undergoing a complete reassessment. Little real evidence exists for the schemes appearing in most text-books at the present time. The identification of large numbers of different forms of organized endings in the circumanal skin and in the epithelium of the anal canal does not, at the moment, help to clarify the position. Nevertheless, this profuse sensory innervation of an epithelial region ought to give pause to the present tendency to scout the functional significance of form in sensory endings.

It is of interest that the epithelial surfaces of the mouth show a great number of endings not dissimilar to those found in the anal region (Gairns and Aitchison, 1950; Gairns, 1955).

To those interested in the function of the rectum and who demand from histologists the demonstration of sensory nerve-endings in the rectal wall, the presentation of one solitary organized ending from all the specimens examined will serve only to emphasize a very vexed problem. There may be in fact very few such endings, or the method used in this work may fail to stain them. It is not easy to accept failure in histological technique when it is remembered that every one of our specimens of the junctional area between the rectal mucosa and the stratified squamous epithelium of the anal canal was passed through the staining procedure as a single entity. Yet stretching of the rectal wall and movement within the rectum are effective stimuli for defæcation. There must surely be receptors of some nature.

This paper, oddly enough, lends support to two rather opposing conceptions of the nature of peripheral receptors. The demonstration of numerous organized receptors of distinctive form in the perianal skin and anal canal tends to support the older idea that sensory modalities can be attributed to specific types of ending: the absence of obvious organized endings in the rectum supports more modern doubts about the ability of histological methods to reveal the nature of peripheral receptors.

The findings in this study are of interest from the clinical point of view. The fact that pain can be felt up to 1·5 cm. craniad to the anal valves emphasizes that any injection for hæmorrhoids should be made at or above the anorectal ring both for efficacy and to avoid producing pain. Most surgeons are aware that sensation extends above the anal valves, but there is little mention of the fact in the standard texts.

We mentioned above that the profuse sensory innervation of the anal canal probably has a part to play in maintaining the reflexes which ensure evacuation of the distal colon and rectum. During defæcation contraction of the colon and of the rectum is associated with relaxation of both the internal and of the external anal sphincters (Garry, 1933; Bishop and others, 1956). However, in man and in animals with a 'social sense', the external anal sphincter must undoubtedly play a part also in the maintenance of anal continence. Gaston (1948 a, b) has emphasized this aspect and shown that in conscious man distension of the rectum may cause relaxation of the internal anal sphincter while at the same time causing contraction of the external anal sphincter. Since the transition from rectal epithelium to the epithelium of the anal canal takes place almost at the anorectal ring (Goligher, Leacock, and Brossy, 1955) relaxation of the internal sphincter with simultaneous contraction of the external sphincter will ensure that the rectal contents will make initial contact of some little duration with the sensitive epithelium of the anal canal.

This contact may signal the nature of the contents of the rectum and give warning of an imminent reflex event which may not be desirable or opportune in the circumstances in which the subject is placed.

This hypothesis would explain, in part at least, the poor anal continence which is a feature after 'pull-through' abdomino-anal resections of the rectum of the Bacon-Babcock type. All patients subjected to this procedure by Goligher (1951, 1955) were incontinent and only about 10 per cent of the series reported by Waugh, Miller, and Kurzweg (1954) were fully continent, the remainder having varying degrees of incontinence, especially for fluid stools. In these operations the entire lining of the anal canal may be removed or the epithelium may be left up to the pectinate line. This means that the most acute sensation of the anal canal is always lost and in some cases none of the anal canal sensibility remains.

A better prospect of continence follows abdomino-anal resection with evagination (the Maunsell-Weir procedure), when about 7 cm. of the rectum, measured from the anus, is left. In these cases the whole anal canal is intact except for the stretching consequent on the operation. The preservation of rectal sensation has been suggested to be the vital factor in maintenance of anal continence in these patients. Using balloon distension of the rectum, Gaston (1948 b) could elicit no sphincteric reflexes from a patient who had all the anal canal removed in an abdomino-anal resection and had equivocal results in another who had 1·5 cm. of rectum left craniad to the anal valves. However, from his testing on 12 normal patients and on 2 patients with rectal remnants of 7–10 cm., he felt that rectal sensation was required for anal continence. The importance of retaining rectal sensation was emphasized by Goligher and Hughes (1951), also on the basis of balloon distension of the rectum after various operative procedures. In both these reports the difficulty of testing the lower rectum near the anorectal ring is mentioned. It seems not unreasonable to postulate that the retention of the sensibility of the anal canal, which would make up about half of the 7-cm. 'rectal' stump in the evagination operation, assists in the maintenance of anal continence.

It can be seen that the sensation and sensory innervation of the anal canal and surrounding perianal skin provide many interesting facets from both theoretical and clinical aspects. The present investigation has brought some of these to light and has emphasized others. However, more work is required, especially from the functional point of view, before the true value of these findings in the normal physiology of the area can be assessed.

SUMMARY

1. The nerves and nerve-endings in the perianal skin in the epithelium of the anal canal and in the mucous membrane of the rectum were stained by a Bielschowsky-Gros silver method. The material was obtained at operation or at autopsy from 10 human subjects. The tissues were removed as continuous strips from perianal skin through the epithelium of the anal canal, and then on to the mucosa of the rectum; they were then carried through the silver impregnation processes while still in continuity.

2. The perianal skin contains only peritrichial endings and free intra-epithelial endings: at the anal margin, however, organized nerve-endings are found in close apposition to hair follicles.

3. The wall of the anal canal has a profuse innervation, especially in the region of the anal valves. This innervation has both free intra-epithelial endings and organized endings, many of which belong to the classical eponymous types, e.g., Golgi-Mazzoni, Krause, Meissner, and Pacinian.

4. The histological technique so successful in the perianal skin and in the wall of the anal canal failed to show endings in the mucosa of the rectum, except on one occasion when an organized ending was seen at its caudal extremity.

5. Sensation was tested in conventional fashion in 15 normal subjects. The epithelium of the anal canal was exquisitely sensitive to pain, to heat, and to cold. Touch was delicate, and movement of an object in contact with the epithelium of the anal canal was at once appreciated.

6. The possible significance of these findings is discussed in relation to (*a*) the allocation of particular modalities of sensation to individual nerve-endings, and (*b*) the act of defæcation and the maintenance of anal continence.

We gratefully acknowledge the keen interest and helpful suggestions of Professor R. C. Garry and Professor C. F. W. Illingworth. We are greatly indebted to Dr. H. S. D. Garven for giving us the benefit of his wide histological experience and for his constructive criticism. To Mr. D. McAllister our thanks are due for his skilful co-operation in the preparation of the photomicrographs and to Mr. R. Callander for the clarity of the text-figures and photodiagrams.

Special reagents were provided by the Rankin Medical Research Fund of the University of Glasgow.

REFERENCES

Bishop, B., Garry, R. C., Roberts, T. D. M., and Todd, J. K. (1956), *J. Physiol.*, **134**, 229.
Cauna, N. (1956), *Amer. J. Anat.*, **99**, 315.
Duthie, H. L., and Gairns, F. W. (1958), *J. Physiol.*, **143**, 1P.
Fan, W. W. (1955), *Arch. jap. Chir.*, **24**, 567.
Gairns, F. W. (1955), *Quart. J. exp. Physiol.*, **40**, 40.
— — and Aitchison, J. (1950), *Dent. Rec.*, **70**, 180.
Garry, R. C. (1933), *J. Physiol.*, **78**, 208.
Garven, H. S. D., and Gairns, F. W. (1952), *Quart. J. exp. Physiol.*, **37**, 131.
Gaston, E. A. (1948 a), *Surg. Gynec. Obstet.*, **87**, 280.
— — (1948 b), *Ibid.*, **87**, 669.
Gilbert, R. W. (1929), *J. gen. Psychol.*, **2**, 445.
Goligher, J. C. (1951), *Ann. R. Coll. Surg. Engl.*, **8**, 421.
— — (1955), *Med. Annu.*, **73**, 365.
— — and Hughes, E. S. R. (1951), *Lancet*, **1**, 543.
— — Leacock, A. G., and Brossy, J. J. (1955), *Brit. J. Surg.*, **43**, 51.
Hagen, E., Knoche, H., Sinclair, D. C., and Weddell, G. (1953), *Proc. roy. Soc.*, **141**, 279.

IZUMI, I. (1955), *Arch. Hist. jap.*, **9**, 225.
KANTNER, M. (1957), *Acta anat.*, **31**, 397.
OTTAVIANI, G. (1940), *Ztcher. f. mikr.-anat. Forsch.*, **47**, 151.
PENDLETON, C. R. (1928), *Amer. J. Psychol.*, **40**, 353.
SETO, H. (1940), *Arb. anat. Inst., Sendai.*, **23**, 133.
SINCLAIR, D. C., WEDDELL, G., and ZANDER, E. (1952), *J. Anat.*, **86**, 402.
SOTELO, J. R. (1954), *Z. Zellforsch.*, **41**, 101.
STRUGHOLD, H. (1925), *Z. Biol.*, **83**, 515.
WALLS, E. W. (1958), *Brit. J. Surg.*, **45**, 504.
WAUGH, J. M., MILLER, E. M., and KURZWEG, F. T. (1954), *Arch. Surg., Chicago*, **68**, 469.

RADIATION IN THE MANAGEMENT OF KELOIDS AND HYPERTROPHIC SCARS

BY H. A. S. VAN DEN BRENK AND C. C. J. MINTY
CANCER INSTITUTE BOARD, MELBOURNE, AUSTRALIA

THE terms *keloid* (from κηλίς, a mark or blemish) and *cheloid* (from χηλή, a crab's claw) apply to cutaneous lesions characterized by an overgrowth of fibrous tissue which is not neoplastic, but tends to combine regenerative and degenerative characteristics which result in an initial overgrowth, followed by slow regression. Cosmetic disturbances may result, together with symptoms of irritation and even interference with function of related parts, and may warrant active treatment.

However, the aetiology of 'spontaneous' and traumatic cutaneous hypertrophies is by no means clear. The term 'keloid' was originally applied by Addison (1854) to a small white opacity (morphœa) which appeared spontaneously in the skin, and spread to surrounding tissues, particularly subcutaneous tissues, giving rise to thickening, puckering, and nodularity, and even contractures and superficial excoriation. The disease was described as progressive over many years and this subcutaneous fibrous overgrowth, termed the *Kelis Addisonii*, is probably identical to scleroderma. The term 'cheloid', first described by Alibert (1814) under the name *kelis* (synonyms, *cheloide* and *cancroide*), refers to a much commoner condition, encountered in surgical practice, and referred to as 'keloid' or more recently, *hypertrophic scar*. The *kelis* of Alibert is essentially an overgrowth of granulation tissue following injury, however trivial, which tends to invade the zone of discontinuity in the skin, and projects above the normal skin contour. Some subcutaneous extension also results, but is more limited than that seen in the kelis Addisonii. Subsequently, the granulation tissue matures, vascularity is reduced, and swelling and hyalinization of the whorls of collagen fibres occur. Despite claims to the contrary, the majority of keloids, or hypertrophic scars, tend to regress slowly over the months or years following injury, provided superimposed trauma or infection is prevented, and provided the other factors, such as endocrine disturbance and foreign-body inclusions, cease to act.

With some reason, it has been claimed that a 'keloid diathesis' exists which predisposes to a failure for wounds, however trivial, to show natural early regression, with restoration of contours. However, the hypothesis warrants discriminative consideration. As Mowlem (1951) has stressed, much of the apparent susceptibility to keloid formations is attributable to regional, anatomical, and physiological differences and endocrine states. Scars subject to undue movement and tension, particularly those that cross cavities, are prone to hypertrophy. Also the continued local irritation caused by inclusion of foreign matter is an important predisposing factor. Mowlem attributes the inclusion of keratin as of particular importance, and lanugo hairs in early childhood may become buried and result in persisting hypertrophic scars. Also the excessive sebaceous gland formation seen at puberty, and in the Negro subject, similarly predisposes to local interference with healing. The predisposition of burns to hypertrophic scarring may be related to an interference with normal wound contraction in burns (van den Brenk, 1956 a), or be due to the inclusion of denatured protein, resulting in chronic irritation and stimulation of repair processes. The normal hypertrophic tendencies of standard surgical wounds, involving the deltoid area, e.g., radical mastectomy, or pubic hair line, e.g., herniotomy, are well recognized and are probably attributable to mechanical factors (lines of skin tension) and histological peculiarities (sweat-gland distribution).

A clear appreciation of the natural history and pathology of hypertrophic scars is important. If natural regression of a hypertrophic scar is the rule, care must be exercised in attributing such natural regression to any therapy. An analysis of case material, in which ionizing radiations were employed in the treatment of conditions, labelled either hypertrophic scars or keloids, has been undertaken in the present paper, with a view to assessing the usefulness of irradiation, with or without surgery, in these conditions. More particularly, however, an attempt has been made to determine from experimental and clinical data the optimal dosage of the radiation to be used and the optimal time of its administration. The clinical experience of the writer has been that radiotherapeutic colleagues recommend dosages and régimes for the treatment of keloids which vary considerably. Similar discrepancies are to be found in the literature.

In order to define the pathological condition under discussion, in referring to 'keloids and hypertrophic scars', the writers invoke the common keloid of

Alibert—a hyperplastic repair state following injury or infection, however trivial, which tends to result in abnormal tissue overgrowth despite restoration of surface continuity after wounding, but which also tends to *regress slowly*, provided the initiating stimulus or other injurious factors, which prevent regression, cease to act. The writers share the opinion of others, that no keloid is truly idiopathic, and so-called 'familial keloids', of which an example will be given, are also attributable to aetiological, anatomical, and functional factors, which constitute the so-called 'keloid diathesis'.

CASE MATERIAL

The case material to be analysed has been obtained from the Records Department of the Peter MacCallum Clinic, Melbourne. Cases of keloids referred by surgical and medical colleagues were treated by several radiotherapists.

Sex and Age Incidence.—The age incidence for the two sexes in 147 consecutive cases is shown in

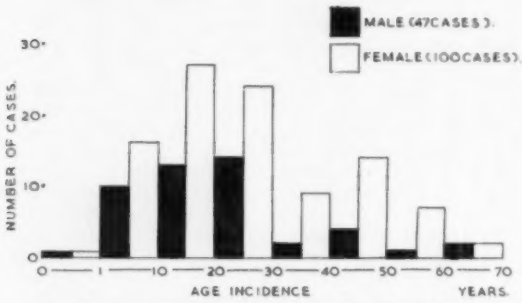


FIG. 600.—Sex and age distribution for cases of keloids and hypertrophic scars referred for radiotherapy.

Fig. 600. More than twice as many female patients with keloids were seen—100 female and 47 male cases presenting for treatment. In both sexes a peak age incidence of keloids occurred between 1 year and 30 years. In males this peak was largely attributable to keloids resulting from burns or accidental injury, whilst for females post-operative keloids were the main group referred for treatment. However, for both sexes this referral for treatment doubtless reflects cosmetic considerations, and the age incidence of cases in this series cannot be taken as representative of the incidence of keloids in general.

Table I.—ANATOMICAL DISTRIBUTION OF KELOIDS AND HYPERTROPHIC SCARS FOLLOWING SURGICAL INCISIONS, ACCIDENTAL WOUNDS, AND BURNS, REFERRED FOR RADIOTHERAPY

REGION	NUMBER OF LESIONS		
	Operations	Non-surgical Wounds	Burns
Face	4	4	10
Neck	17	2	10
Chest	13	3	17
Abdomen	17	—	1
Extremities	8	17	38
TOTAL	59	26	76

Causation.—In 140 patients the keloid followed a definite cause. The results are given in *Fig.* 601 and *Table I.* The majority of keloids developed after surgical incisions, accidental wounds, or burns. The regional distribution of the lesions seemed more closely related to exposure to the particular trauma than to any anatomical predisposition to keloid formation. Additional miscellaneous causes were

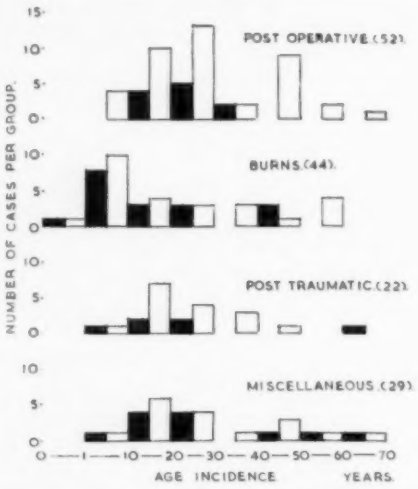


FIG. 601.—Sex and age distribution of individual lesions (keloids and hypertrophic scars) based on aetiology.

infections (10), diathermy and caustics (3), vaccination sites (3), donor skin-graft sites (3), and recipient skin-graft sites (3). In only 7 cases were the lesions 'spontaneous', no apparent aetiological factor being recorded.

Multiple Keloids.—In 17 male and 25 female patients multiple lesions were present, the majority following burns. It is interesting to record that in 2 cases keloid formations developed in radionecrosis (*see below*). In 2 cases a familial tendency to keloid formation seemed apparent, the lesions following very slight injuries and the predisposition continuing into adult life. In both cases facial and physical characteristics noted at examination suggested negroid ancestry, but this was not proven.

RADIOTHERAPEUTIC RESULTS

Analysis of the response of keloids to ionizing radiations may be divided into two categories: (1) Cases of established lesions treated by primary irradiation without surgery; and (2) Cases treated by definitive surgery (excision) combined with planned prophylactic irradiation (pre-operative, post-operative, or in combination). Whilst a simple yardstick as to the effectiveness of treatment may be adopted in the second group, in terms of recurrence of the lesion the response of an established lesion to

radiation is most difficult to decide, and depends on the criteria used by different observers as to what constitutes a good or poor response. The fact that hypertrophic scars and so-called 'keloids' have an *inherent tendency towards spontaneous regression* can easily lead to the incorrect assumption that regression is due to therapy.

Primary Irradiation without Surgery.—For an established keloid a good response to radiation treatment has been arbitrarily defined as *complete flattening, softening, and paling of the lesion within six months after the first irradiation treatment.* Concomitant atrophy is ignored in this assessment (*see below*) and it is felt that the time interval of six months allowed for assessment is most generous, in view of the natural regression which normally takes place without treatment. Changes short of a 'good response' such as 'softening', 'slight flattening', 'paling', etc.—descriptions often encountered in clinical progress notes, and repeated month after month—have to be ignored as an objective response to treatment, although it is freely admitted that palliation may result, in the absence of objective response, from relief of pruritus and irritation.

1. *Single Course Treatments.*—The results in 56 cases, treated with a single dose of X rays, are set out in *Table II* together with the follow-up periods after

Table II.—Lesions treated with Single Course of X-ray Therapy

Total Dose	Number of Lesions (per cent)			
	Cure* (within 6/12)	'Softening'	'Slight Softening' or 'No Change'	Total
400 r	1 (8)	3 (23)	9 (69)	13 (100)
400–700 r	1 (5)	6 (30)	13 (65)	20 (100)
700–1000 r	4 (31)	5 (38)	4 (31)	13 (100)
1000 r	3 (30)	3 (30)	4 (40)	10 (100)
Total	9 (16)	17 (30)	30 (54)	56 (100)

* Term 'cure' is used according to definition in text, and alternatively to 'good response'.

Follow-up Period (in months) in 56 Cases†

Follow-up Period (months)	3	3–6	6–9	9–12	12
Number of Cases	12	5	7	10	22

† In 8 additional cases no follow-up (excluded).

Age of Lesions in relation to Cure Rate

'Age' of Keloid (months)	2 wk.	2–4 wk.	1–3 mth.	3–6 mth.	6–12 mth.	12 mth.
Total Number (Number of Cures)	0 (0)	4 (2)	7 (4)	25 (3)	11 (0)	11 (0)

treatment, and the relation of 'good responses' to the age of the keloid at the time of irradiation. From these results the following conclusions may be drawn:—

a. Only 16 *per cent* of treatments (9 of 56 cases treated) gave 'good responses'. This poor result is further offset by the finding that early superficial radionecrosis resulted in 2 cases (625 r and 940 r respectively), and in 1 case (940 r) late radionecrosis resulted, with recurrent keloid forming in the area of necrosis. In a further 6 cases thickening increased some time after treatment and surgical excision was performed.

b. Seven of 9 'good responses' resulted after higher dosage (in excess of 700 r).

c. 'Good responses' only occurred for keloids treated at earlier stages of development (less than 4 months).

d. Follow-up periods of less than 6 months in 17 of 56 cases may have been insufficient to evaluate a 'good response', but even if all such cases had responded well, the total 'good responses' would have been raised to only 44 *per cent.*

2. *Multiple Course Treatments.*—In *Table III* the results in cases treated with two courses of X-ray therapy are given, and analysed with reference to total dosage and time interval between courses. In 4 of 28 cases showing 'good response', complete flattening and paling of the lesion was observed 3, 4, 4, and 6 months respectively after the last radiation treatment, and it is quite clear that most of such 'good responses' may be attributable to natural regression. In 4 cases, which received total doses of 780, 1040, 1800, and 1850 r respectively, a special mention of adjacent tissue atrophy was recorded, and in 1 case (a child) disturbance of limb growth resulted.

Eight cases received total doses ranging from 1000 to 3000 r in three courses spaced over 2–9 months, and in 4 cases regression (flattening and paling) was recorded 6, 6, 12, and 12 months respectively after the initial radiation treatment. One case received 2500 r in six sessions over 13 months, when its continued presence still demanded treatment, which was rendered by means of excision combined with pre- and post-operative X-ray therapy, after which no recurrence took place.

It may be concluded that the results of primary irradiation of keloids have been poor, and the 'good responses' following irradiation are largely attributable to clinical bias, natural regression, masking by regional atrophy in the whole irradiation zone, and symptomatic relief of pruritus and irritation. The actual cosmetic benefit resulting from the irradiation in cases of established keloid is clearly dubious, and does not conform with results obtained from clinical and laboratory experimentation (*see below*). Incomplete, partial regression of the hypertrophic tissue attributable to irradiation was commonest in recent 'active' keloids and scars, and after higher radiation doses.

Post-operative Irradiation.—In this group results of a combined treatment (excision of the keloid, and irradiation of the scar *before* recurrent keloid had developed) were easy to assess in terms of recurrence, which takes place soon after simple excision in most cases. The results for single-dose treatments variously applied within 9 days to 4 weeks of definitive excision of the keloid are given in *Table IV* for 15 cases. No case showed a complete florid recurrence; 5 cases showed partial recurrence, and in 9 cases no recurrence occurred. One case received 1700 r, which resulted in *radionecrosis, which subsequently healed*

with keloid formation. Most of the 'cured' cases (7 of 9 cases) received doses of 1000 r or more. In 6 cases (*Table IV*) fractionated post-operative therapy was used; in 2 cases recurrence was prevented, in 4 cases recurrence resulted. In 2 cases combined pre-operative and post-operative X-ray therapy was used, 275 r/800 r and 320 r/320 r respectively, and recurrence was prevented.

Table III.—Lesions treated with Two Courses of X-ray Therapy

Total Dose	Time between Courses					
	Less than 3 months		*3–6 months*		*Over 6 months*	
	Good Response	Poor Response	Good Response	Poor Response	Good Response	Poor Response
500–1000 r	1	2	0	5	0	3
1000–1500 r	3	2	0	2	0	0
> 1500 r	0	3	0	4	0	3
Total	4	7	0	11	0	6

It may be concluded that the combined surgery-radiation technique is a more certain and efficient method of dealing with hypertrophic scars and keloids than primary irradiation, and creates no additional hazard attributable to irradiation. It is the only irradiation discipline for these lesions, in which results can be assessed, with a measure of objectiveness and confidence, and divorced from clinical bias. Its rationale is also more ably supported by radio-biological principles and experiment (*see below*).

Table IV.—Post-operative Therapy—Response of Lesions which received Radiotherapy to Scar between 9 days and 4 weeks, after Planned Excision of the Keloid

Single Dose Treatments (15 *Cases*)

Dose	No Recurrence	Partial Recurrence	Recurrence	Total
500 r	0	1	0	1
500–750 r	1	1	0	2
750–1000 r	1	3	0	4
1000 r or more*	7	0	0	7

* 1 additional case (1700 r) radionecrosis with keloid formation.

Single Course Treatments (6 *Cases*)

Dose Fractionation	Result
600 r (6 wk.)	Partial recurrence
1700 r (3 wk.)	Partial recurrence
675 r (3 wk.)	Keloid recurred
600 r (2 wk.)	Keloid recurred
1200 r (4 dy.)	No recurrence
1300 r (8 wk.)	No recurrence

In order to draw attention to the efficacy with which early post-operative irradiation prevents hypertrophic changes in a surgical scar, the following case history (illustrated in *Fig.* 602) is presented.

Case 1.—A. B., a child, aged 5 years, received a course of post-operative deep X-ray therapy following nephrectomy for a nephroblastoma. The radiation therapy was commenced to the upper abdominal area 3 days after nephrectomy, before the sutures were removed, and only covered the lower portion of the incision. The wound healed uneventfully, but the upper unirradiated portion rapidly developed hypertrophic thickening which persisted, whilst the portion of the incision included in the radiation field was completely clear of this change (*Fig.* 602). This portion of the incision received a high-incident skin dose of 2530 rads over 27 days. The radiation reaction which developed, and its resolution, is seen in the illustrations, together with persistence of the 'keloid' in the unirradiated portion of the incisional scar.

A B

Fig. 602.—Effect of early post-operative irradiation of a surgical wound in prevention of keloid (*Case* 1). Photographs show the reaction in irradiated skin (A), its resolution (B), and the sharply delineated characteristics of irradiated and non-irradiated portions of the wound.

PATHOLOGICAL AND EXPERIMENTAL STUDIES

Pathological Aspects.—In the genesis of a hypertrophic scar, whilst the initiating factors remain uncertain, the early histological changes clearly consist of a rapid growth of the repair blastema (granulation tissue), consisting of advancing capillary sprouts and proliferating fibroblasts, which demolish and organize the fibrin clot and wound debris (*Fig.* 603). Epithelial migration accompanies this growth and covers the repair blastema, but in hypertrophic wounds early maturation with cessation of growth is delayed, and the repair tissues project beyond the normal skin contours as epithelialized fleshy masses of tissue, with some extension into the surrounding subcutaneous layer, underlying the marginal pre-existing epithelium. At an early stage the 'keloid' consists of a pink, vascular, cellular tissue (*Fig.* 604) which rapidly fibrifies with deposition of collagen, and a concomitant reduction in the cellular (fibroblast)

index occurs. With time the 'keloid' becomes paler, as maturation proceeds, vascular remodelling with a reduction in the vascular index takes place, and gradual thickening, some fragmentation, and hyalinization of the whorled collagen bundles occur (*Fig.* 605). Under ordinary circumstances of slow natural regression, which may last for many months, this process of maturation proceeds, the lesion reduces in thickness by a process of contraction, to be surrounded by looser, normal areolar tissue, giving a 'softened' texture to the lesion and its immediate environs. Patchy calcification of the original lesion may occur. If inflammatory or mechanical stimuli become operative during maturation, a certain degree of 'activation' may take place which leads to varying degrees of abeyance of normal maturation, inflammation, and even recurrence.

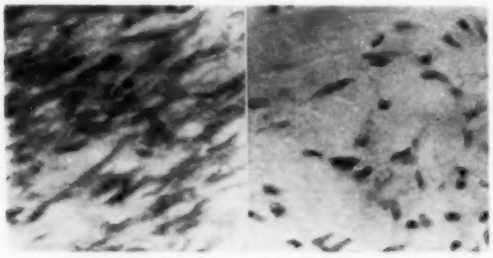


FIG. 603.—Migrating fibroblasts in granulation tissue of healing wounds in skin of rat, 5 days after injury. A, Unirradiated wound showing dense fibroblast population and polar distribution of cells. B, Irradiated wound (2000 rads X rays applied as single tissue dose immediately after injury) showing sparse, irregular cell distribution, degenerating cells, and œdematous matrix. Methylene blue stain. (× 300.)

The events which have been described lead to a delineation of two phases in the natural history of a hypertrophic scar:—

1. *Regeneration*—the early, proliferative cellular and vascular changes.

2. *Regression*—the slow maturation of cells and vessels, with reduction of cellularity and vascularity, and physical changes in the stroma.

The regenerative changes closely parallel the growth of a repair blastema when observed *in vivo* in the Sandison Clark rabbit's ear chamber, a preparation which can be used to study rates of growth of granulation tissue (van den Brenk, 1956 a) by allowing the repair blastema to organize from the periphery, a small space of known dimensions filled with physiological fluid enclosed between the base and cover-slip of a perspex chamber inserted in the living animal, and observed microscopically.

Radiosensitivity of Repair Tissues in Experimental Ear Chambers.—The writer has carried out a series of investigations reported elsewhere (van den Brenk, 1956 a, 1956 b, 1957 a, 1957 b, 1959), in which the *growing* repair blastemata in Sandison Clark ear chambers were exposed to graded doses of X rays and γ rays (^{60}Co), and the effect on their growth determined. It was found that the dose–effect relationship is strictly threshold, and that doses of less than 2000 r fail substantially to inhibit the growth of the normal repair blastema. In *Figs.* 606 and 607 examples are given of two ear chambers exposed to single doses of 1000 r and 4000 r respectively, with continued regeneration after irradiation in the former and inhibition of growth in the latter.

Allowing for species differences in radiosensitivity between rabbit and man, it would follow that a *single dose of the order* 1500 r is necessary substantially to inhibit regenerating normal granulation tissue in

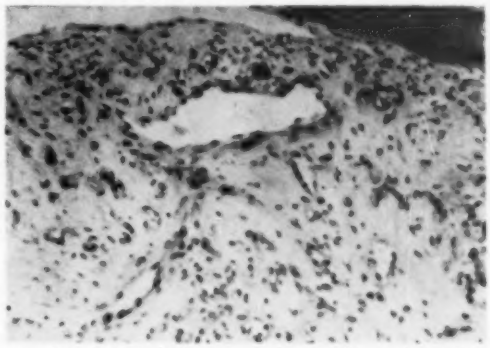


FIG. 604.—Early pink, vascular hypertrophic scar in female patient showing newly formed capillaries and vessels amid cellular stroma and covered by epithelium. Hæmatoxylin and eosin stain. (× 100.)

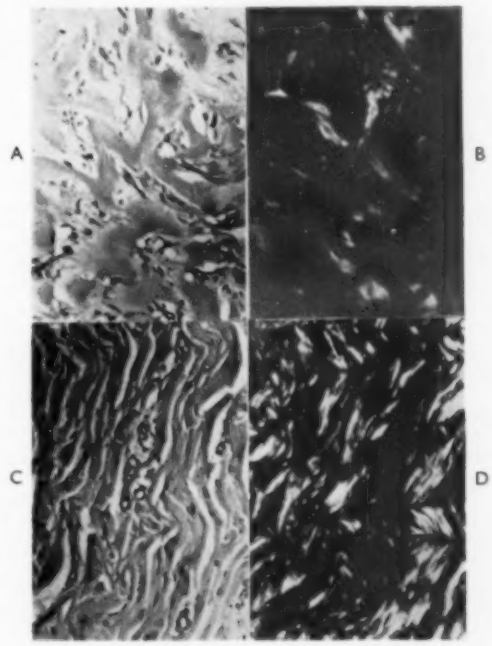


FIG. 605.—Representative sections taken from an excised mature keloid, showing hyalinized, fragmented collagen of centre of lesion (upper photographs, A, B) and normal collagen bundles from dermis adjacent to lesion (lower photographs, C, D). The photographs on the left (A, C) have been taken with ordinary light, and the photographs on the right (B, D) are the corresponding microscopical fields taken with polarized light, to demonstrate the difference in amount and distribution of birefringent collagen (white in photographs). Hæmatoxylin and eosin sections. (× 130.)

similar circumstances in man. However, it has been found that if *existing* granulation tissue is exposed to much larger doses (4000 r γ rays), subsequent partial destruction of this irradiated tissue allows for an *uninhibited formation and regeneration* of a repair blastema, from the remaining irradiated tissue zone, a process which has been termed '*super-regeneration*' (*see* van den Brenk, 1959, for details). This means that the cells of heavily irradiated mechanocyte (and epithelial) tissues, in which signs of radiation atrophy are evident, have not lost their inherent power to regenerate, provided adequate stimuli are exhibited. These findings essentially explain the reasons for *keloid formations which may occur in radionecrosis* (*see below*). It is of interest that, following the atomic disasters of Hiroshima and Nagasaki, irradiated survivors commonly showed keloid scars resulting from injury and burns.

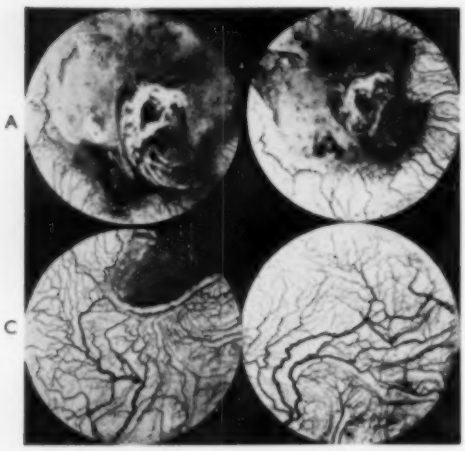


FIG. 606.—Growth of repair blastema ('granulation tissue') in rabbit's ear, observed in Sandison Clark ear chamber (number 35R) following exposure to single tissue dose of 1000 r (γ rays, ^{60}Co source). A, Immediately preceding irradiation—partial regeneration from periphery. B, 9 days after irradiation—normal regeneration occurring. C, 30 days after irradiation—further regeneration. D, 48 days after irradiation—complete regeneration of chamber space (*note* extensive remodelling of vascular pattern).

Hypertrophic Tissue Formations after Irradiation.—To illustrate in humans the process of 'super-regeneration' following irradiation described above in relation to experimental studies, the following case history is presented:—

Case 2.—Female, aged 54 years, received intensive X-ray therapy to the lower abdomen and pelvis for a large intra-abdominal mass. The total dose received was 7800 r to the skin over a period of four years, and resulted in marked atrophy of the lower abdominal wall and skin. Eight years later a limited patch of radionecrosis developed in the skin of the centre of the hypochondrium, which separated and was followed by an ulcerated granulomatous formation, projecting above the level of the surrounding atrophic abdominal skin. This tissue bled freely, and was suspected to be an extension of the intra-abdominal neoplasm. However, repeated biopsies only showed granulation tissue in radionecrosis and eventually an excision of most of the irradiated atrophic abdominal wall was performed, and the defect covered by a large rotation flap. Good healing resulted. *Histological examination* of the excised tissue showed a typical vascular granulomatous tissue formation in the centre of irradiated atrophic, partly hyalinized connective tissue, which organized the necrotic zone, as a hypertrophic tissue formation (*Fig.* 608).

This case provides an example of intense irradiation of skin resulting in late zonal radionecrosis, followed by a florid 'healing' with the formation and regeneration of connective-tissue cells and vascular sprouts, *in continuity and derived from previously irradiated host tissues*. It follows that *pre-operative irradiation*, designed to prevent or subdue regenerative processes, is a somewhat unreliable procedure, which depends on non-recovery of a growth potential in irradiated tissues at the time of surgery. If such recovery has taken place 'super-regeneration' may occur and result in recurrent keloid formation. 'Super-regeneration' implies an intrinsic competence for repair in surviving irradiated tissues, if a suitable local stimulus (injury) is supplied. Whilst secondary factors may jeopardize such super-regeneration, its manifestations are sufficiently established to permit the onset of regeneration after spontaneous radionecrosis, or the onset of more or less normal focal repair, after injury to surviving irradiated tissues.

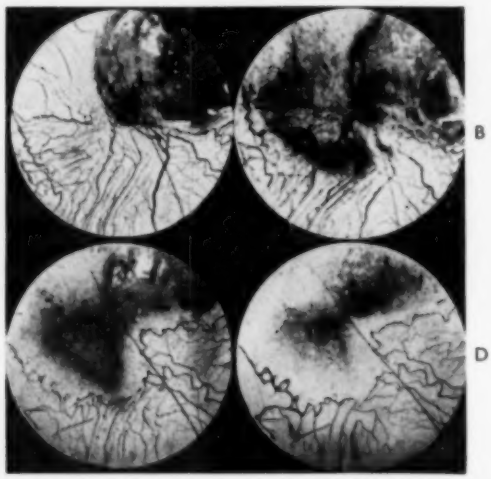


FIG. 607.—Similar preparation to *Fig.* 606 exposed to single tissue dose of 4000 r (γ rays, ^{60}Co source). Chamber number 43R. A, Immediately preceding irradiation. B, 3 days after irradiation—growth inhibited and considerable destruction of most recently formed (immature) regenerating tissues. C, 15 days after irradiation—some remodelling and formation of terminal vascular arcade, bordered by pale 'fibrous barrier', with ineffectual aberrant capillary sprouting. No significant regeneration. D, 57 days after irradiation—no significant regeneration since irradiation, marked reduction of vascular index in formed regenerate but very little remodelling of larger vessels compared with 1000-r dose (*Fig.* 606).

Radiation Dosage for Inhibition of Repair in Human Skin.—The clinical results have shown that excision of keloids, followed by *immediate* or *early irradiation*, during the active growing phase of the repair process, is the most reliable method of preventing recurrence of a hypertrophic state (*see above*). However, the dose used must be carefully chosen. The inhibition of vascular regeneration is a threshold dose–effect relationship, with a minimum effective dose in man, which from experimental

results in ear chamber studies, was predicted to be approximately 1000–1500 r (single tissue dose). Since reliable clinical information on this point was lacking, a case of multiple keloids referred for treatment was used for a clinical experiment:—

Case 3.—A male, aged 22 years, had suffered for several years from multiple 'keloids' following acne of the trunk.

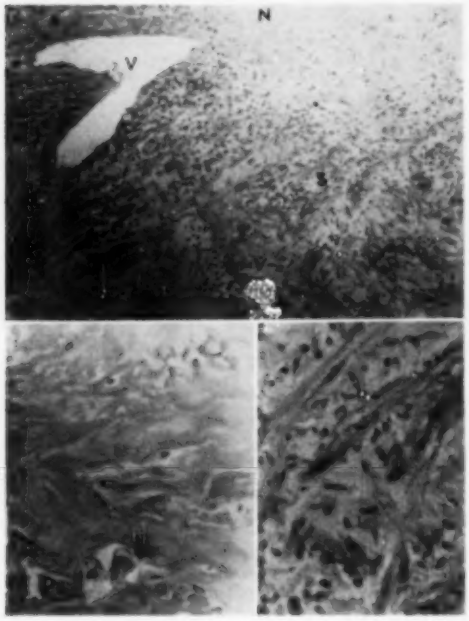


FIG. 608.—Sections taken from zonal hypertrophic granulation tissue formations following radionecrosis (*Case* 2). A, Low-power view (× 42), showing atrophic dermis at A, merging into necrosis (N), and telangiectatic 'feeder' vessel (V) from which active capillary sprouts (S) originate, accompanied by fibroblasts and round-cell infiltration. B, High-power view (× 180) of zone A (radiation atrophy). C, High-power view (× 180) of capillary sprouts in zone S. Hæmatoxylin and eosin sections.

At the time of presentation, developing, established, and regressing keloids were present in large numbers and six lesions on the dorsum were chosen, which were approximately equal in size, thickness, and colour (*Fig.* 609).

Three of the six lesions were excised, without approximation, and two of the three wounds treated 72 hours after excision with single doses of 500 r and 1000 r (140 kV., 8 mA., 4 mm. Al H.V.L.) respectively, the third being unirradiated. The remaining three intact lesions were exposed to 500, 1000, and 1500 r X rays respectively. Similar untreated lesions were observed as controls. The patient has been kept under close observation for the past two years and the progress of individual lesions carefully recorded and photographed. The results of the various treatments are illustrated in *Figs.* 610 and 611 and are given:—

1. *Keloid treated with Primary Irradiation* (without excision).—

500 r: Slight erythema at 2 weeks, no regression attributable to irradiation; slow regression identical with untreated control lesions, with a pale, flattened, softened plaque resulting after 12 months.

1000 r: Definite erythema at 2 weeks, some pigmentation of irradiated skin, no regression of keloid attributable to irradiation. At 12 months as for 500 r, but slight atrophy of surrounding irradiated skin.

FIG. 609.—*Case* 3. Multiple keloids following acne of trunk. The six lesions selected for treatment by irradiation only, excision, or excision followed by irradiation within 72 hours, have been marked on the skin with circles and the respective treatments are labelled. Note pitting of skin due to previous acne keloids which have regressed without treatment. (*Figs.* 610, 611 show the response of selected keloids to treatments in this case.)

1500 r: As for 1000 r, but marked radiation atrophy of skin surrounding keloid. No significant true regression of keloid; apparent regression due to masking by regional atrophy.

Table V.—RESULTS IN 23 CASES OF KELOIDS AND HYPERTROPHIC SCARS PRIMARILY TREATED WITH RADIUM PLAQUES, RADON MOULDS, AND INTERSTITIAL RADON NEEDLE IMPLANTS, WITH OR WITHOUT ADDITION OF X-RAY THERAPY

Age-group (years)	Number of Cases	Result (Objective Response)			Complications		
		Good	Partial	Nil	Radio-necrosis	Severe Atrophy	Severe Disturbance of Bone Growth
0–1	1	—	—	1	—	1	1
1–6	5	—	3	2	—	3	2
6–10	1	—	1	—	—	1	—
10–18	3	—	1	2	2	2	—
18	13	1	6	6	2	4	—
Total	23	1	11	11	4	11	3*

* All three cases followed radon moulds or combined X-ray and radium plate therapy.

2. *Excision of Keloid, followed within 24 hours by Irradiation of Entire Wound.*—

No Irradiation: Healing followed by recurrent keloid, slow natural regression of recurrent keloid over following 12 months.

depressed, thin, pigmented scar surrounded by a margin of atrophic skin.

The results recorded in this case, and illustrated in *Figs.* 609–610, give direct support to results from

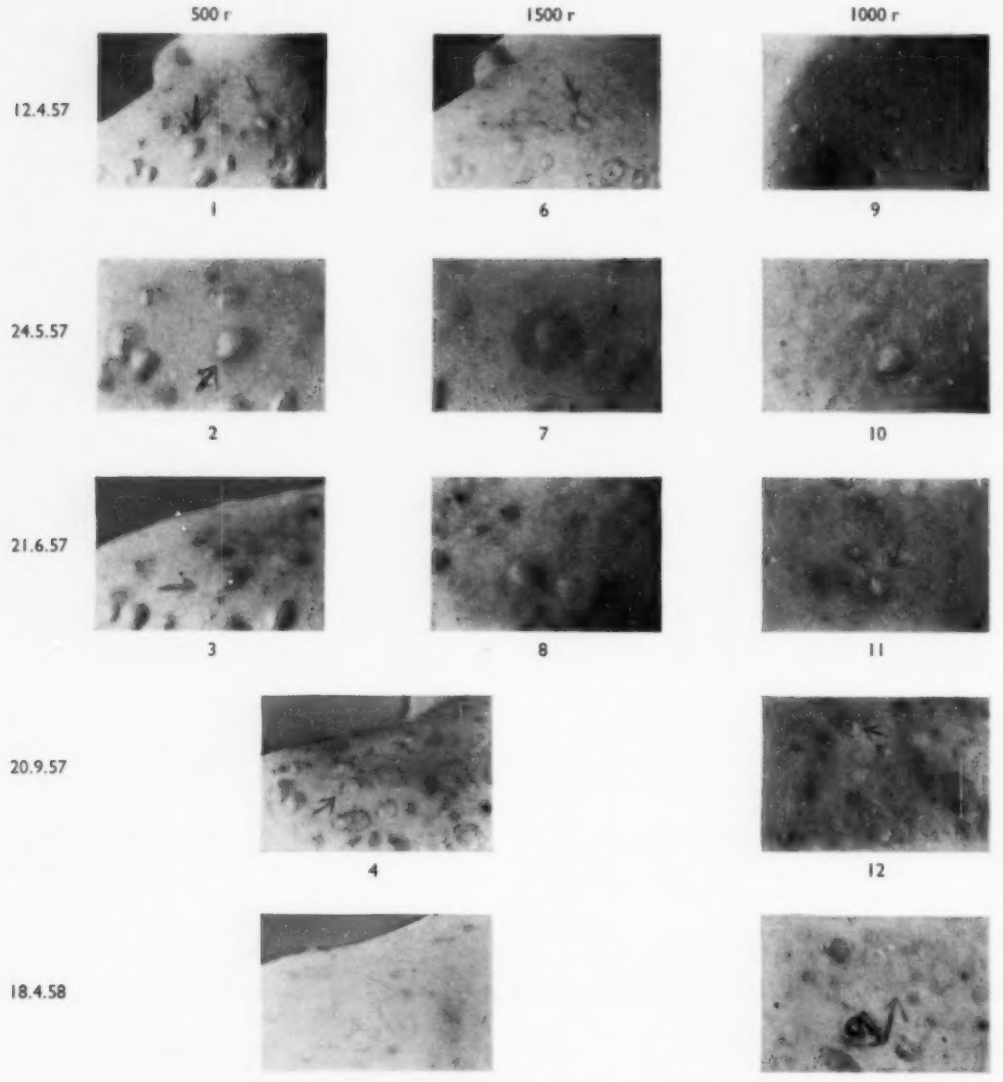


FIG. 610.—*Case* 3. Response of three selected keloids to irradiation only, with doses of 500 r (photographs 1, 2, 3, 4, 5), 1000 r (9, 10, 11, 12, 13), and 1500 r (6, 7, 8, 4, 5) respectively. *See* key for lesion in *Fig.* 609. Note: (1) Radiation erythema for 1000 and 1500 r (9 and 6 respectively); (2) Early pigmentation and atrophy for 1000 and 1500 r (10 and 7 respectively); (3) Paling and spontaneous regression of both treated and untreated lesions at 5 months (4, 12) and twelve months (5, 13).

500 r: Healing followed by a partial recurrence. Subsequent atrophy of irradiated tissues with a depressed pigmented scar.

1000 r: Healing without recurrence of keloid, but marked atrophy of irradiated tissues, resulting in a

animal experiments. Primary irradiation of established keloids fails to cause selective regression of the actual lesion—a result consistent with the pathological characteristics and radiobiological principles

involved. Natural regression of the lesion and zonal radiation atrophy account for any objective 'good responses' recorded. On the other hand, whilst early post-operative irradiation with doses of 1000 r or more prevents recurrence, radiation atrophy is a necessary consequence.

Radiation Hazards associated with the Treatment of Keloids.—An analysis of 23 additional cases, primarily treated with external or interstitial radium or radon sources, with or without

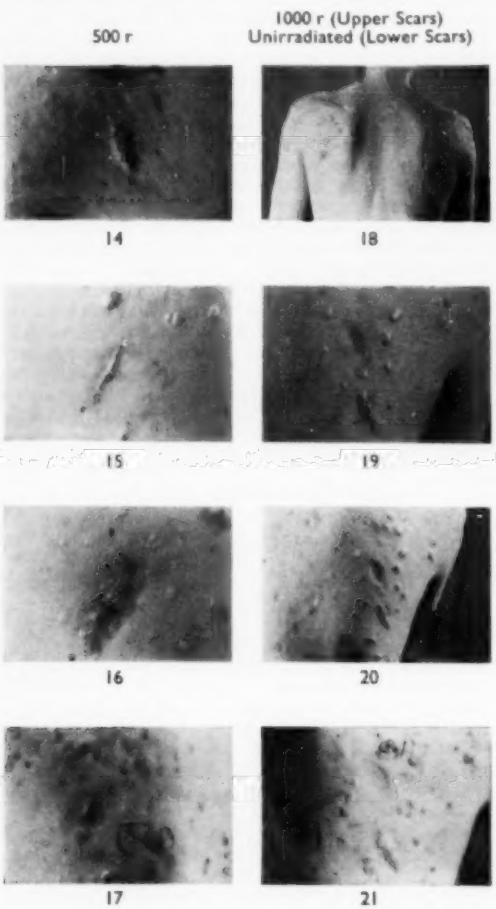


FIG. 611.—*Case* 3 (key, *see Fig.* 609). Response of three selected keloids to excision followed by irradiation 72 hours later in two lesions; unirradiated (lower scars in 18, 19, 20, and 21) shows pronounced keloid in scar with paling but residual thickening at 12 months; 500 r (14, 15, 16, 17) shows recurrent keloid, but less than in unirradiated scar; 1000 r (upper scars in 18, 19, 20, and 21) shows complete absence of recurrence of keloid, but a depressed scar due to radiation atrophy.

X-ray therapy, is set out in *Table V*. These cases were treated in an earlier period, before X-ray therapy became conventional, and emphasize the hazards which may follow intense irradiation with hard X rays or gamma rays, particularly in children. However, the analysis also emphasizes that even at this early period it was realized that high doses were needed for an objective result.

Severe interference with bone growth, due to X-ray therapy of keloids, is illustrated by the following example:—

Case 4.—A male child, aged 16 months, suffered from burns of the neck and right hand, with subsequent keloid changes. Fifteen weeks after injury the keloids were treated with X-ray therapy (200 kV., H.V.L. 0·25 mm. Cu, 10 mA.) using large fields (7·5 cm. in diameter), and doses (measured in air) of 400 r were given to the fingers and hand, opposing surfaces each receiving a total of 1600 r over a period of one week. The total tissue dose received by the growing bone of the lower radius and ulna, carpus, metacarpus, and phalanges was probably of the order of 1000–2000 r in one week. Generalized atrophy of the whole of the irradiated hand, wrist, and forearm resulted,

FIG. 612.—*Case* 4. Showing hypoplasia and inhibition of bone growth of hand and forearm at age of 18 years, due to local irradiation of keloids following burns at the age of 16 months. (Estimated dose to bones 1000–2000 r in one week.)

and at the age of 18 years the irradiated bones were hypoplastic, and comparison of radiographs of right and left upper limbs showed 1 cm. shortening of irradiated metacarpals and 1·5 cm. shortening of irradiated forearm bones. A photograph of the patient's hands and forearms at the age of 18 years is shown in *Fig.* 612.

Whilst the quality of the radiation used in *Case* 4 was unsatisfactory, the dose employed was of an order required for inhibition of repairing tissues, but clearly far in excess of tolerance of normal bone growth. It can be stated unequivocally that therapeutic irradiation of keloids in children is a most hazardous undertaking.

Even the use of the softest available qualities of X rays is dangerous, particularly over large areas and thin integument covering bones of the fingers, etc. Attempts to reduce the dose to the bone only result in totally ineffective dosage of the skin lesion. Furthermore, the dose of radiation received by skin for effective treatment of a keloid or hypertrophic scar must cause atrophy and the risk of radiation-induced malignant change in skin (or deeper structures) in later life.

Whilst no case of bone sarcoma following therapeutic irradiation of a keloid or hypertrophic scar has been recorded in this clinic, the hazard nevertheless exists and must be given due recognition.

The employment of high-dosage irradiation in attempts to attain an objective result in terms of tissue atrophy also invites radionecrosis, particularly

with larger areas, and is clearly contra-indicated. This complication in adequate post-operative irradiation of a linear approximated incision, with adequate but minimal margin, has not been encountered, and associated atrophy is reduced to a minimum volume and favours an overall good cosmetic result.

DISCUSSION

This paper has been primarily written to elucidate, from clinical and experimental data, the rationale of radiation treatment of keloids and related conditions and particularly to determine optimal dosage and the critical time of its delivery. To-day considerable confusion still attends the radiotherapy of keloids, and dosage régimes have been advocated by radiotherapists and dermatologists which differ widely, and often pay insufficient heed to pathological and radiobiological factors, the natural history of the disease, and the distinction between specific radiosensitivity of the lesion in question and non-specific radiation atrophy.

Pinch (1925) recommends half-strength radium application for 4–6 hours on each of three successive days, this radiation session being repeated every two months until the "absorption of the keloidal mass" is complete and "skin tint restored to normal". Carter Braine (1929) states no dose, but recommends treatment of "small keloids by radium and large keloids by medium or high voltage X rays", and that "heavy filtration is necessary", and that exposures have to be repeated at monthly to six-weekly intervals. Erskine (1947) makes the truly remarkable statement that "X-ray treatment is almost uniformly successful in dissolving the excessive fibrous tissue of keloids"; that "the plan sometimes advised of excising the keloidal scar and applying X rays to the incision during the process of healing is rarely if ever necessary", and recommends 600–700 r every six weeks and from one to ten treatments, i.e., treatment may be necessary for more than one year, with a total dose not less than 6000 r. Aird (1949) specified no dosage, but simply states that keloids are highly radiosensitive. Wallace (1941) recommends 3000 r given as fractionated treatment over a period of six weeks for established keloids, but seems to favour post-operative treatment. Dazzi and Boeri (1958) use 80–200 r fractions of 60–130 kV. X rays, given on alternate days to a total dose of 800–2000 r, the session being repeated every 45–60 days, to a maximum total of four cycles.

Other authors clearly favour surgery combined with irradiation. Wallace (1941) recommends a single dose of 400 r within 10 days of operation, to "hinder excessive proliferation of collagen". Mowlem (1951) specifies a dose of X rays immediately before operation, and a second dose 7 days after operation, the total dose seldom exceeding 750 r. Allan and Keen (1954) give 800 r before operation and 1200 r on the tenth day after operation, and consider that higher doses are required in the Bantu native. A most complicated régime is selected by Belisario (1957): a multiple modality consists of a course of 10–12 injections of hydrocortisone acetate and hyaluronidase administered weekly into or under the lesion; after the last injection, the lesion is shaved to skin level or excised and sutured, a hydrocortisone-neomycin-hyaluronidase ointment is applied to the wound twice daily post-operatively and a concurrent course of X-ray therapy is commenced immediately after surgery and consists of 150–400 r fractions administered over 2–3 months, to a total dose of 1200 r.

It is extremely difficult to reconcile most of the recommendations and views expressed above with the results recorded and illustrated in this paper. It seems necessary to conclude that many authors fail adequately to recognize natural regression of hypertrophic scars, confound non-specific radiation atrophy with the specific radiosensitivity of keloid and hypertrophic tissues, and fail clearly to state the criteria used to classify response to treatment. Also unsatisfactory are rationales and régimes recommended in the radiotherapeutic treatment of other vascularizing reparative states such as retinitis proliferans, pterygium, and Peyronie's disease, to which fundamental studies of the repair blastema and its radiosensitivity apply equally. Much of the confusion is due to quantitative experimental evidence not being available till recently, when the dose–effect relationships for inhibition of the growth of repair blastemata were made available for animal tissues (van den Brenk, 1956 b, 1959). However, it seems strange that the belief can exist that small fractionated doses of irradiation are capable of dissolving or reducing in size an established keloid, which largely consists of poorly vascularized, hyalinized collagen, and very few cells, showing even fewer mitotic figures, i.e., a non-proliferating and relatively acellular tissue in which the oxygen tension is almost certainly low—factors which predispose to radio-resistance.

CONCLUSIONS

The results obtained in *Case* 3 clearly support the experimental findings described in animals. The following conclusions are drawn:—

1. Primary irradiation of an established keloid, without surgery, may relieve symptoms such as pruritus, but fails to cause resolution of the actual lesion. If higher doses are employed (1000 r or more as a single dose), atrophy of the whole irradiated volume may cause partial masking of the keloid. If the dose is sufficiently high to result in radionecrosis, recurrent keloid may result.

2. Primary irradiation of very recent keloids, which are still cellular, well vascularized, and growing, may cause some resolution of the lesion if the dose employed exceeds 1000 r single dose. Any resolution, following doses less than 1000 r, is largely accounted for by natural regression of the lesion.

3. Owing to the time intervals involved for development of a keloid after injury, there is no place for the use of fractionated small doses of radiation to attain a larger cumulative dose, based on recovery factors.

4. Pre-operative irradiation is open to the objections that:—

a. The volume irradiated must be necessarily large to ensure that the *entire* surgical wound (in both depth and extent) is contained within the irradiated volume and with an adequate margin.

b. The rapid recovery from radiation effects of tissues capable of repair—particularly the property of cellular migration—readily gives rise to super-regeneration and recurrence.

5. Post-operative irradiation administered *before* the repair blastema and epithelial tissues have grown sufficiently to establish a recurrent hypertrophic thickening is the most efficient radiation technique for prevention of recurrent hypertrophic scars and keloids. However, for certainty in prevention of keloid, the dose employed must lie between 1000 and 1500 r single tissue dose. This dose invariably causes atrophy of cutaneous tissues, which is often unsightly, and, if sufficiently widespread, subject to the hazard of late radionecrosis in certain circumstances. The radiation is preferably administered within 48 hours of surgery, to an accurately approximated wound, with a margin of 0·5 cm. of normal skin. If the wound breaks down owing to mechanical factors or infection, recurrence of keloid is still usually prevented, provided the irradiated margin has been sufficient. However, healing may be delayed.

6. The dose of 1000–1500 r used post-operatively should not be fractionated, for reasons outlined under (3) above, i.e., owing to the rapidity with which the tissues regenerate and the threshold radiation response of repair tissues to irradiation.

7. Growth of bones in young children will be reduced by single doses of radiation of less than 400 r, and the treatment of keloids in children is contraindicated in those situations where the growing bone (metaphysis) may receive even minimal amounts of radiation.

SUMMARY

1. The results and rationale of the use of ionizing radiations in the treatment of hypertrophic scars and keloids are presented.

2. The results of cogent experimental and pathological studies are described and illustrated.

3. The early post-operative application of a single tissue dose of radiation not less than 1000 r is the only reliable procedure in preventing recurrence of keloids and hypertrophic scars. However, this dose will cause cutaneous atrophy.

4. The danger of an effective irradiation dose in causing retardation of bone growth in children is emphasized.

5. The 'good responses' attributed to primary irradiation (without surgery) of established keloids largely result from spontaneous natural regression of such lesions and the masking effect of irradiation atrophy. However, small doses of radiation do appear to cause subjective relief of symptoms, but a real objective response seldom results.

Acknowledgements.—The authors wish to thank the Medical Director, Peter MacCallum Clinic, for access to the records of patients used in this paper; Dr. G. R. Kurrle for photographs used in *Fig.* 602; Mrs. K. Elliott and Miss D. O'Reilly for photographic illustrations, and Mrs. I. Tamosaitis for secretarial assistance.

REFERENCES

ADDISON, W. (1854), *Trans. med.-chir. Soc.*, **38**, cited by ERASMUS WILSON (1883), in *Quain's Dictionary of Medicine*. London: Longmans & Sons.

AIRD, I. (1949), *Companion in Surgical Studies*, 78. Edinburgh: E. & S. Livingstone Ltd.

ALIBERT, M. (1814), *Clinique de l'Hôpital Saint Louis ou Traité Complet des Maladies de la Peau, Paris*, cited by ERASMUS WILSON (1883), in *Quain's Dictionary of Medicine*. London: Longmans & Sons.

ALLAN, J. C., and KEEN, P. (1954), *S. Afr. med. J.*, **28**, 1034.

BELISARIO, J. C. (1957), *Acta Dermat. Venereol.*, **37**, 165.

BRAINE, J. F. CARTER (1929), *Recent Advances in Surgery* (ed. Ogilvie), 2nd ed., 406. London: Churchill.

DAZZI, C., and BOERI, F. (1958), *Abstr. World Med.*, **24**, 394 (abstr. 1246).

ERSKINE, A. W. (1947), *Practical X-ray Treatment*, 91. St. Paul: Bruce Publishing Co.

MOWLEM, R. (1951), *Brit. J. plast. Surg.*, **4**, 113.

PINCH, A. E. HAYWARD (1925), *A Clinical Index of Radium Therapy*, 119. London: Harrison & Sons Ltd.

VAN DEN BRENK, H. A. S. (1956 a), *Brit. J. Surg.*, **43**, 525.

— — (1956 b), *Progress in Radiobiology*, 386. Edinburgh: Oliver & Boyd.

— — (1957 a), *Proc. Coll. Radiol. Aust.*, **1**, 29.

— — (1957 b), *Amer. J. Roentgenol.*, **78**, 837.

— — (1959), *Ibid.*, **7**, 859.

WALLACE, A. B. (1941), *The Treatment of Burns*, 69. London: Oxford University Press.

THE MANAGEMENT OF CAROTID BODY TUMOURS

WITH A REPORT OF SEVEN CASES

BY G. WESTBURY, LONDON

CONSULTANT SURGEON, WESTMINSTER HOSPITAL

IN the eighty years since Riegner (reported by Marchand, 1891) first excised a tumour of the carotid body more than 300 cases have been described, and the abundant literature has been well reviewed in a number of collective studies (Phelps, Case, and Snyder, 1937; Gratiot, 1943; Monro, 1950; Uggeri, 1957).

The treatment of carotid body tumours nevertheless remains controversial. Situated, as they are, in intimate relation to the carotid bifurcation, their surgery is attended by the hazard of cerebral ischæmia. Left alone the patient runs the risks of a progressively enlarging tumour, of uncertain innocence, in the neck.

Harrington, Clagett, and Dockerty (1941) believed that all these lesions were malignant or potentially so and recommended that the carotid arteries should be sacrificed where necessary at operation. Pettet, Woolner, and Judd (1953), on the other hand, basing their views on a large series from the Mayo Clinic, considered surgical treatment to be more dangerous than the disease, and Warren

(1953) also doubted in most instances the justification for removing the tumour at the expense of the vessels.

Opinion on treatment, however, must be modified as knowledge of the natural history of the tumour increases and as surgical and ancillary techniques improve. The opportunity to study 7 histologically verified cases seen at the Westminster Hospital since 1951 has prompted a reassessment of problems concerned with their management.

FIG. 613.—*Case* 1. Appearance in April, 1959.

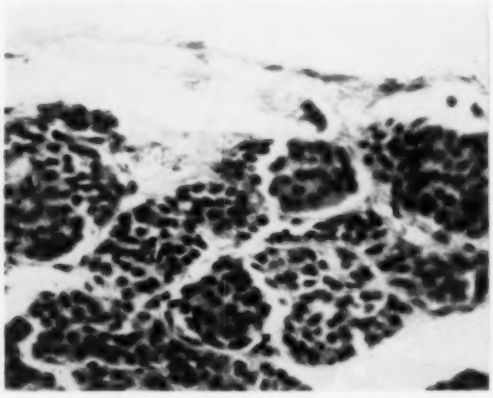


FIG. 614.—Original tumour in *Case* 1, showing alveolar pattern and capsule. Hæmatoxylin-eosin. (× 266.)

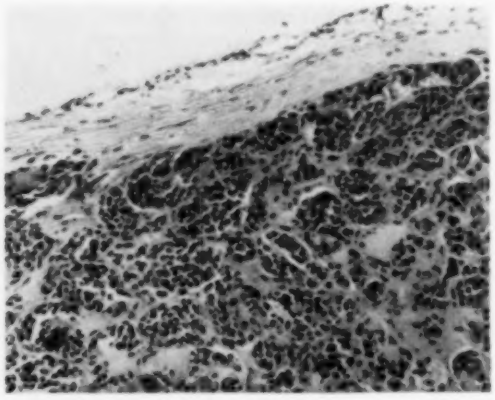


FIG. 615.—Supraclavicular metastasis from *Case* 1, with close resemblance to primary tumour. Hæmatoxylin-eosin. (× 106.)

THE BEHAVIOUR OF THE TUMOUR

Carotid body tumours are generally slowly growing and encapsulated. Monro (1950) calculated that the average duration of symptoms before presentation was 7 years, and total histories of 30 years or more are well known.

These tumours sometimes reach a large size and may extend medially towards the pharynx, causing dysphagia. They can involve the vagus or hypoglossal nerves, the sympathetic chain, or the cervical plexus. The carotid sinus syndrome is occasionally observed. *Case* 6 of this series was unusual in presenting symptoms of intermittent carotid artery insufficiency.

The occurrence of frank malignancy has been doubted, but direct invasion of surrounding structures and spread to lymph-nodes and by blood-stream are well documented (Goormaghtigh and Pattyn, 1954; Romanski, 1954; Fernán Zegarra, 1957; Friedman and Lau, 1957; Rabson and Elliott, 1957). Monro (1950) reckoned that local recurrence after operation or metastasis took place in 12 per cent of cases, and that where resection had to be abandoned the tumour led to the patient's death in 30 per cent of instances. He found no certain correlation between the histological findings and clinical behaviour, and Romanski expressed a similar opinion. The estimate by Harrington and others (1941), based on histological appearances, of an incidence of malignancy of 50 per cent is certainly too high.

Case 1 (*Fig.* 613) showed identical, benign histological appearances both in the primary tumour and in the supraclavicular metastasis removed six years later (*Figs.* 614, 615). In *Case* 7, where local recurrence occurred 7 years after an apparently complete excision, the microscopical picture was also innocent. In *Case* 3 the primary tumour, present for twenty years, showed a regular alveolar pattern (*Fig.* 616); a metastasis in the neck is illustrated in *Fig.* 617, where although traces of organoid arrangement remain, there is considerable loss of differentiation. This patient finally became paraplegic, with a deposit in the lumbar spine, and died. Autopsy revealed no other primary tumour and the diagnosis of malignant carotid body tumour metastasizing by lymphatics and blood-stream is accepted.

DIAGNOSIS

In none of the present series was a correct preoperative diagnosis recorded by the referring

surgeon. Tuberculosis of lymph-nodes, metastatic carcinoma, and branchial cyst were considered. In 4 instances the nature of the tumour was suspected from the naked-eye appearances at exploration, and it was realized only after examination of the sections in the remaining 3 cases.

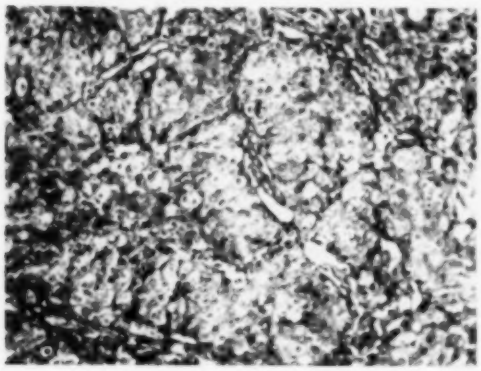


FIG. 616.—*Case* 3. Primary tumour. Hæmatoxylin-eosin. (× 150.)

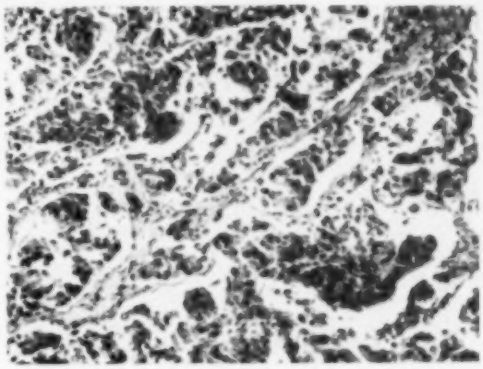


FIG. 617.—*Case* 3. Metastasis from the neck. Hæmatoxylin-eosin. (× 90.)

This experience is in accord with that of many authors and emphasizes the importance in differential diagnosis of awareness of the possibility of this relatively uncommon lesion.

Typically a firm, lobulated, often symptomless tumour is present at the carotid bifurcation, movable from side to side but not up and down, and perhaps showing expansile pulsation and associated with an audible bruit. Monro (1950) quotes Vaughan Hudson's observation that this is the only example in this region where a large vessel (the external carotid) can be felt pulsating in front of the tumour. This sign was present in *Cases* 1 and 5.

Bilateral carotid arteriography was performed in the last 3 cases and demonstrated characteristic findings (Idbohrn, 1951; Engström and Hamberger, 1957; Lipschitz, 1958). *Fig.* 618 (*Case* 6) shows a mass of pathological vessels enveloping the carotid bifurcation, narrowing and displacing backwards the internal carotid artery. This investigation may be the only means pre-operatively of distinguishing a tumour from an internal carotid aneurysm and also provides information on the cerebral cross-circulation. Engström and Hamberger, by means of bilateral arteriography, discovered a second, contralateral carotid body tumour clinically unsuspected.

Drill biopsy is not recommended in view of the closeness of the main vessels and the frequent vascularity of the tumour. Where uncertainty exists, or when on exploration a tumour is found unexpectedly to surround the carotid vessels, an open biopsy should be done and the diagnosis established histologically before proceeding further without full preparation for assessment of collateral circulation and for vascular reconstruction (*see below*).

THE SURGICAL PROBLEM

The carotid body lies deep to the bifurcation of the common carotid artery or wedged between the origins of the internal and external carotid arteries, and is attached to, or partly embedded in, their outer fibrous coat. Carotid body tumours therefore are generally closely adherent to the carotid bulb or the commencement of its two major branches and may grow to encircle the vessels.

FIG. 618.—Left carotid arteriogram in *Case* 6. Note pathological tumour vessels and displacement backwards and narrowing of internal carotid artery.

They can involve the internal jugular vein and the closely related nerves and may not be removable without sacrificing one or other structure. The vagus was divided, alone in *Case* 5 and with the hypoglossal nerve in *Case* 6. In neither patient was respiratory difficulty encountered, although Conley (1956) and others have reported the need for temporary tracheostomy in these circumstances.

The tumour is sometimes easily separated from the main vessels, though division of the external carotid artery, often the main source of the blood-supply of the tumour, may be necessary (*Cases* 2 and 4).

Gordon-Taylor (1940) pointed out that where the tumour at first seemed inseparably adherent to the carotid arteries, patient dissection in the 'white line' of cleavage deep to the adventitia would often permit removal without damaging the vessels. This was corroborated by Morfit, Swan, and Taylor (1953) and by Farrar, Kirklin, Judd, and Devine (1956), who described how a tumour surrounding the arteries could be split to allow this manœuvre. In *Case* 6 dissection in the subadventitial plane allowed complete removal of the tumour, the internal carotid remaining intact.

By such methods an increasing proportion of successful excisions has been achieved without injury to the carotids, but there remains a residue of cases in which the tumour cannot be taken away without sacrificing these important arteries.

THE COMPLICATIONS OF CAROTID INTERRUPTION

The mortality of carotid resection for carotid body tumour has in the past been in the region of 30 per cent and a proportion of the survivors are left with a degree of neurological damage varying from slight weakness of one limb to complete hemiplegia.

The onset of hemiplegia not uncommonly is delayed for 48 hours and has occurred as late as 6 days post-operatively. Dandy (1942), discussing carotid ligation for intracranial aneurysm, attributed such delayed phenomena to distal thrombosis or embolus. MacComb (1948) and Pemberton and Livermore (1951) on these grounds advised giving anticoagulants when the carotid was tied. Their views were opposed by Schorstein (1940) and by Moore and Baker (1955), who believed that late complications were the result of variations in cerebral blood-flow depending on the general circulatory state. Both authors noted the increased incidence of complications in shocked patients undergoing carotid ligation for hæmorrhage and stressed the importance of blood-volume replacement. Schorstein recommended the use of the Trendelenburg position post-operatively to augment cerebral blood-flow; 2 of Moore and Baker's patients became hemiplegic shortly after getting out of bed in the early post-operative period and the same sequence of events occurred in *Case* 5. Resection of the carotid bifurcation was necessary also in *Case* 6, who was nursed flat for 7 days after operation and recovered without incident.

It is impossible to predict with certainty which patients will suffer complications after carotid interruption. The Matas test, while advocated by Dandy (1942), has repeatedly been found to be unreliable: symptoms following digital compression of the common carotid may in part be due to carotid sinus stimulation. A negative Matas test, on the other hand, even though carotid compression is applied for 30 min. or more, cannot exclude the possibility of delayed hemiplegia.

Rogers (1944) used electro-encephalography as a control during temporary carotid occlusion, but no definite conclusions can be drawn from his small, uncomplicated series. Potter and Taylor (1955) employed this technique in 33 ligations for intracranial aneurysm, but found no correlation between changes in the tracings and the subsequent clinical course.

The last authors also confirmed that arteriographic demonstration of cerebral cross-circulation provided no guarantee against post-operative hemiplegia (*see Case* 5), while failure to outline the vessels of the opposite hemisphere did not necessarily imply that complications would follow ligation.

A more accurate means of determining the adequacy of cerebral flow after carotid ligation was indicated by Sweet, Sarnoff, and Bakay (1950). They studied intracarotid pressures at operation after occlusion of the internal (or sometimes common and external) carotid. In a series of 26 patients their 2 deaths occurred in those 3 cases with a fall in pressure to 30 per cent or less of pre-occlusion values. Johnson (1953) confirmed these important findings; in his group of 11 patients with intracranial aneurysm, hemiplegia occurred during a 30-min. period of trial occlusion in 3 patients among 5 whose post-occlusion pressures dropped by 60 per cent or more. This technique of assessment could be used without difficulty at operation for carotid body tumour, employing a fine polythene catheter introduced into the common carotid artery below the tumour.

MEASURES TO REDUCE THE RISKS OF CAROTID RESECTION

Stimulation of Collateral Flow.—Intermittent pre-operative compression of the common carotid artery against Chassaignac's tubercle has long been practised as a means of improving the cerebral collateral circulation. Staged ligation, practised by Dandy (1942) and others, has the same object. The effectiveness of prolonged digital compression is, however, open to doubt (Sweet and others, 1950), and Mann, Herrick, Essex, and Baldes (1938) have shown in experiments little fall in carotid flow until the lumen of the artery has been reduced by more than 50 per cent. In any case an important contribution to any increase in collateral circulation may be derived from the external carotid which is necessarily sacrificed in resection of the bifurcation.

There is little evidence that division of the cervical sympathetic materially improves the cerebral circulation (Kety, 1958).

Vessel Grafting.—Arterial continuity should be restored wherever possible. Even when all the evidence suggests a good cross-circulation, the outcome of ligation is uncertain and, furthermore, these tumours may be bilateral (Lewison and Weinberg, 1950; Lahey and Warren, 1951; Engström and Hamberger, 1957).

Direct anastomosis of the common to the internal carotid artery may occasionally be possible, but vascular replacement will usually be required, by autogenous vein, homologous artery, or plastic prosthesis. Successful vessel grafting has been reported by Conley (1957), Crile and Humphries (1957), and others.

The insertion of a preserved, deep-frozen artery homograft was attempted in *Case* 6, but failed owing

to the closeness of the upper pole of the tumour to the skull base.

The Value of Hypothermia.—Surface cooling to 29–30° C. was used during operation in the last 2 cases. The period of safe exclusion of the carotid vessels was thereby extended, enabling the possibility of insertion of a graft, should it have been necessary, by simple suture. This was preferred to special techniques for rapid anastomosis such as that described by Soltero and Greenberg (1958).

The experimental studies of Rosomoff (1955) suggest that where arterial continuity cannot be restored hypothermia may confer a further advantage. He showed that the incidence of cerebral damage in dogs undergoing ligation of the middle cerebral artery was greatly lowered by cooling and suggested that the reduction in cerebral metabolic rate gave added time for establishment of the collateral circulation.

Post-operative Position: Use of Anticoagulants.—The importance of keeping the patient flat in bed, or head down when the carotid must be tied, has already been discussed. The possible value of anticoagulant therapy in limiting cerebral thrombosis after ligation has to be balanced against the considerable danger of hæmorrhage in a recent surgical wound.

RADIOTHERAPY

Carotid body tumours are generally radio-resistant (Harrington and others, 1941; Hendrick, 1942; MacComb, 1948; Kline, Thomas, and McNamara, 1949; Morfit and others, 1953; Fletcher and Arnold, 1954). *Case* 1 confirms this experience and although considerable irradiation change is evident histologically in *Case* 5 (*Fig.* 619), the tumour continued to increase in size in spite of treatment. In *Case* 3 teleradium therapy led to transient regression only and six months later blood-borne metastasis was evident.

A few examples of response to radiotherapy have been published (Bevan and McCarthy, 1929; Stewart, 1931; Hartmann, 1936; Doermann and Meffley, 1953). Lahey and Warren (1951) reported a case where the tumour increased in size while under treatment with conventional X rays, but later responded to 2 MeV therapy.

CONCLUSIONS: RECOMMENDED SCHEME OF MANAGEMENT

The potential dangers of carotid body tumours are sufficiently great to warrant an aggressive rather than conservative attitude towards treatment.

Clinical diagnosis may be confirmed by arteriography; if doubt remains final proof should be obtained by open biopsy before embarking on an operation likely to damage the carotid trunk.

Operation should be carried out under hypothermia and facilities for arterial pressure recording and vessel grafting should be available.

The treatment of choice is complete removal with preservation of the common and internal carotid arteries.

Where the tumour is inseparable from these vessels the ideal management is resection of the carotid bifurcation with restoration of arterial continuity, usually by a graft. The limiting technical factor will be the closeness to the skull base of the required point of transection distally.

Where grafting is judged to be impossible the carotid bifurcation should be sacrificed only if the internal carotid pressure falls less than 60 per cent after common and external carotid occlusion. In this event the patient should be nursed flat or head down for at least one week post-operatively. It is considered that the dangers of anticoagulant therapy outweigh any possible benefit. Other methods to assess pre-operatively the safety of carotid interruption are unreliable, as are those purported to increase cerebral collateral flow.

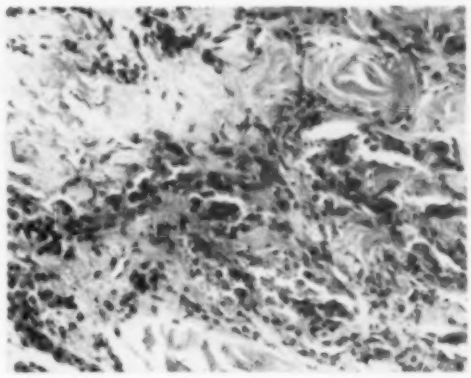


FIG. 619.—Fibrosis and nuclear atypicality following irradiation in *Case* 5. Hæmatoxylin-eosin. (× 125.)

Radiotherapy, preferably supervoltage, may be of palliative value for inoperable or metastasizing tumours.

CASE REPORTS

Case 1.—Mr. F. C., aged 38 years, had, in 1944, a mass removed from the right side of the neck, adherent to the great vessels. It was thought to be a metastasis from an undetected squamous-cell carcinoma and post-operative deep X-ray therapy was given to the neck.

He presented again in July, 1951, with a mass of 'glands' in the right side of the neck. These were excised except for one adherent to the carotid bifurcation. Review of this material and of the original slides showed a carotid body tumour (*Fig.* 614).

The residual mass has slowly grown and now fills the side of the neck from jaw to clavicle (*Fig.* 613). There are no symptoms other than occasional pain.

Biopsy of a supraclavicular node in November, 1957, showed appearances identical with the original (*Fig.* 615).

Case 2.—Mr. R. L., aged 45 years, presented in December, 1953, with a lump in the right side of the neck of five years' duration. It was thought to be a branchial cyst. Exploration revealed a vascular tumour, 1 in. in diameter, intimately connected with the carotid sheath; attempted removal was abandoned after considerable hæmorrhage.

The neck was re-explored one month later and the mass excised with sacrifice of the external but preservation of the internal carotid artery. Histologically this was a typical carotid body tumour.

When last seen in April, 1959, there was no sign of recurrence.

Case 3.—Mr. A. G., aged 58 years, was first seen at Westminster Hospital in February, 1954, with twenty years' history of a swelling in the right anterior triangle of the neck. Since June, 1953, a chain of lumps had

appeared adjacently and recent biopsy showed a carotid body tumour (*Fig.* 616).

He was treated with the 10-g. teleradium unit to a tumour dose of approximately 3500 r with brief, temporary regression, but by August, 1954, the cervical masses were much larger and fixed.

In September, 1954, he became paraplegic owing to a metastasis in the first lumbar vertebra and he died in January, 1955. At autopsy a mass of neoplastic tissue was present in the right side of the neck and the body of the first lumbar vertebra was collapsed owing to a metastasis. Histology from the neck is shown in *Fig.* 617.

No other primary tumour was found and this is believed to be a case of malignant carotid body tumour with metastasis by lymphatics and by blood-stream.

Case 4.—Mr. B. S., aged 31 years, presented in August, 1954, with a mass in the right side of the neck, thought clinically to be tuberculous lymph-nodes. Exploration showed a fleshy, lobulated tumour, 2 in. in diameter, embracing the carotid bulb and origins of its two major branches. The tumour was excised completely, the external carotid being sacrificed but the internal carotid preserved. Histology confirmed the operative diagnosis of carotid body tumour.

There was no evidence of recurrence when last examined in April, 1959.

Case 5.—Mr. D. T., then aged 19 years, underwent removal of a lump from the right side of the neck in September, 1949. A recurrence was explored in September, 1950, noted to lie at the carotid bifurcation, but was not removed. Deep X-ray therapy (250 kV.; 5000 r tumour dose in one month) was given, with no regression.

By March, 1956, the tumour had gradually enlarged to 3 in. in diameter. Bilateral carotid arteriography showed a vascular tumour in relation to the right carotid bifurcation, and a good cross-circulation was demonstrated.

In April, 1956, the tumour was excised with sacrifice of the carotid bifurcation and the intimately adherent vagus and sympathetic nerves. The patient was well for the first 48 hours, but on the third post-operative morning he was mistakenly allowed out of bed and shortly afterwards complained of weakness and clumsiness of the left upper limb. He was immediately put back to bed flat and two weeks later had recovered all except skilled movements of the left hand.

Histology showed a carotid body tumour with marked post-irradiation changes in some fields (*Fig.* 619).

When seen in March, 1959, there was no recurrence but slight residual weakness was present in the left hand.

Case 6.—Mrs. E. E., then 20 years old, first noted a lump in the left side of the neck in October, 1955. She sought medical advice and the neck was explored in August, 1957; a tumour was found surrounding the carotid bifurcation, but its attempted removal was abandoned owing to hæmorrhage.

In November, 1957, when two months pregnant, she experienced a transient episode of blurring of vision, tingling of the right side of the face and tongue, and weakness and paræsthesiæ of the right upper limb. Similar attacks occurred in March and April, 1958, and the lump was increasing in size. Bilateral carotid arteriography showed a vascular tumour surrounding the carotid bifurcation, with displacement backwards and narrowing of the internal carotid. A free cross-circulation was demonstrated.

In May, 1958, under general anæsthesia with surface cooling to 30° C., the tumour was explored. It was intimately adherent to the carotid bifurcation and to the vagus and the hypoglossal nerves, all of which were sacrificed. Attempted insertion of a deep frozen artery homograft failed because the distal carotid stump was too short.

The patient was nursed head down initially and not allowed to sit up for one week after operation.

She recovered without incident and in July, 1958, was delivered spontaneously of a healthy female infant. Both mother and child were well when last examined in February, 1959.

Case 7.—Mrs. H. N., then aged 33 years, noted a lump in the right side of the neck in 1946. This was removed in 1952 and histology showed a carotid body tumour. Recurrence became apparent three years later.

In February, 1959, under general anæsthesia with surface cooling to 29·5° C., the mass was re-explored. It was adherent to the internal carotid, but dissection from it in the subadventitial plane was possible. The external carotid artery and internal jugular vein were sacrificed.

The patient was well when seen three months later.

Acknowledgements.—I am indebted to Sir Stanford Cade for permission to study these cases, all of whom were under his care. I would like also to thank Sir Geoffrey Jefferson for advice in *Case* 5 and Dr. J. W. Bull for the arteriogram; Mr. Harold Burge, who made available clinical details and pathological material from *Case* 3; Dr. G. F. Swann, who performed arteriography in *Cases* 6 and 7; Dr. C. F. Scurr, who conducted the hypothermia and gave valuable advice; Dr. A. D. Morgan and Dr. D. H. Mackenzie, who reviewed the sections; and the Department of Medical Photography, Westminster Hospital, for the illustrations.

REFERENCES

BEVAN, A. D., and MCCARTHY, E. R. (1929), *Surg. Gynec. Obstet.*, **49**, 764.
CONLEY, J. J. (1956), *Arch. Otolaryng., Chicago*, **63**, 229.
— — (1957), *Ibid.*, **65**, 437.
CRILE, G., jun., and HUMPHRIES, A. W. (1957), *Amer. J. Surg.*, **94**, 649.
DANDY, W. E. (1942), *Arch. Surg., Chicago*, **45**, 521.
DOERMANN, E. L., and MEFFLEY, W. H. (1953), *J. int. Coll. Surg.*, **20**, 761.
ENGSTRÖM, H., and HAMBERGER, C. A. (1957), *Acta otolaryng., Stockh.*, **48**, 390.
FERNÁN ZEGARRA, L. (1957), *Rev. Pat. Clin.*, **2**, 171.
FERRAR, T., KIRKLIN, J. W., JUDD, E. S., and DEVINE, K. D. (1956), *Arch. Surg., Chicago*, **72**, 595.
FLETCHER, W. E., and ARNOLD, J. H. (1954), *Amer. J. Surg.*, **87**, 617.
FRIEDMAN, E. W., and LAU, R. (1957), *J. Mt Sinai Hosp.*, **24**, 633.
GOORMAGHTIGH, N., and PATTYN, S. (1954), *Amer. J. Path.*, **30**, 679.
GORDON-TAYLOR, G. (1940), *Brit. J. Surg.*, **28**, 163.
GRATIOT, J. H. (1943), *Int. Abstr. Surg.*, **77**, 177.
HARRINGTON, S. W., CLAGETT, O. T., and DOCKERTY, M. B. (1941), *Ann. Surg.*, **114**, 820.
HARTMANN, H. (1936), *Mém. Acad. Chir.*, **62**, 1404.
HENDRICK, J. W. (1942), *Surgery*, **31**, 385.
IDBOHRN, H. (1951), *Acta radiol., Stockh.*, **35**, 115.
JOHNSON, H. C. (1953), *Surgery*, **33**, 537.
KETY, S. S. (1958), *Circulation*, 332. Oxford: Blackwell Scientific Publications.
KLINE, P. S., THOMAS, R. A., and MCNAMARA, W. L. (1949), *Amer. J. Surg.*, **77**, 120.
LAHEY, F. H., and WARREN, K. W. (1951), *Surg. Gynec. Obstet.*, **92**, 481.
LEWISON, E. F., and WEINBERG, T. (1950), *Surgery*, **27**, 437.
LIPSCHITZ, R. (1958), *Brit. J. Radiol.*, N.S., **31**, 105.
MACCOMB, W. S. (1948), *Ann. Surg.*, **127**, 269.
MANN, F. C., HERRICK, J. F., ESSEX, H. E., and BALDES, E. J. (1938), *Surgery*, **4**, 249.

MARCHAND, F. (1891), *Internationale Beiträge zur wissenschaftlichen Medicin.* Festschrift Rudolf Virchow, Berlin, vol. I, p. 535.
MONRO, R. S. (1950), *Brit. J. Surg.*, **37**, 445.
MOORE, O., and BAKER, H. W. (1955), *Cancer, N.Y.*, **8**, 712.
MORFIT, H. M., SWAN, H., and TAYLOR, E. R. (1953), *Arch. Surg., Chicago*, **67**, 194.
PEMBERTON, J. de J., and LIVERMORE, G. R. (1951), *Ann. Surg.*, **133**, 837.
PETTET, J. R., WOOLNER, L. B., and JUDD, E. S. (1953), *Ibid.*, **137**, 465.
PHELPS, F. W., CASE, S. W., and SNYDER, G. A. C. (1937), *West. J. Surg.*, **45**, 42.
POTTER, J. M., and TAYLOR, F. M. (1955), *Arch. Neurol. Psychiat., Chicago*, **74**, 414.
RABSON, A. S., and ELLIOTT, J. L. (1957), *Surgery*, **42**, 381.
ROGERS, L. (1944), *Brit. J. Surg.*, **32**, 309.
ROMANSKI, R. (1954), *Amer. J. Path.*, **30**, 1.
ROSOMOFF, H. L. (1955), *Fed. Proc.*, **14**, 125.
SCHORSTEIN, J. (1940), *Brit. J. Surg.*, **28**, 50.
SOLTERO, L. R., and GREENBERG, S. D. (1958), *Amer. Surg.*, **24**, 567.
STEWART, H. H. (1931), *Brit. J. Surg.*, **19**, 114.
SWEET, W. H., SARNOFF, J., and BAKAY, L. (1950), *Surg. Gynec. Obstet.*, **90**, 327.
UGGERI, C. (1957), *Arch. ital. Chir.*, **82**, 54.
WARREN, K. W. (1953), *Surg. Clin. N. Amer.*, **33**, 677.

INTERVERTEBRAL DISK PROTRUSIONS IN CHILDHOOD AND ADOLESCENCE*

BY JOHN E. A. O'CONNELL

DEPARTMENT OF NEUROLOGICAL SURGERY, ST. BARTHOLOMEW'S HOSPITAL, E.C.1

THE occurrence of intervertebral disk protrusions in childhood and adolescence has excited relatively little comment in the extensive literature which is concerned with these lesions. Experience suggests that the clinical picture occasioned by disk protrusions at this period differs from that in adults and that a review of the records of a group of children and adolescents with surgically proven disk protrusions might have practical value. Moreover, the careful examination of one small facet of the larger problem of intervertebral disk lesions might contribute something to knowledge of the subject as a whole. As a preliminary to such a review the age range to be considered must be defined. Childhood extends from birth to puberty, that is, 12 years in girls and 14 years in boys. Adolescence extends from 12 to 21 years in girls and from 14 to 25 years in boys. The occurrence of disk protrusion in the latter years of adolescence (18–24 years) is sufficiently common to excite no comment, and for the purpose of this review cases developing symptoms in childhood or the earlier part of adolescence, being aged 17 years or younger, will alone be considered.

Wahren (1945) reported the excision of a lumbosacral disk protrusion from a girl of 12 years. Key (1950) described 2 patients, girls of 12 and 14 years, from whom he had excised lumbar disk protrusions. On the basis of this experience he considers that in children and adolescents "signs are often greater than symptoms" and wonders if this does not lead to the diagnosis being overlooked in this particular age-group. He notes that neurological abnormality is slight or absent. Webb, Svien, and Kennedy (1954) investigated the incidence in childhood (in their view under 16 years) of lumbar disk protrusions in a series of 6500 patients operated upon during a 10-year period. There were 5 patients in childhood so defined, 4 girls and 1 boy, and another 20 aged 16 or 17 years. It is noted that in the 5 youngest patients neurological abnormality was frequently absent. Myelography was performed in every case. Fernstrom (1956) mentions 3 patients treated by him, all girls, 1 of 11 and 2 of 17 years. The first of the three, the youngest recorded case to be submitted to surgical treatment, had had symptoms for two months and had a typical clinical picture. This author points out that of the 9 recorded patients under the age of 16 years, 8 were females, a very different sex incidence from that in adults.

In addition to these reports of intervertebral disk protrusions in the age period 11 to 17 years, a number of examples of calcification of the nucleus pulposus with at times extrusion into the spinal canal of the calcium-rich fluid nucleus have been recorded (Walker, 1954; Bjelkhagen and Gladnikoff, 1957). This calcification of the nucleus pulposus may occur in any portion of the spine, being particularly common in the thoracic region. In this age-group it is temporary only, and indeed radiological examination demonstrates that it may be very rapidly absorbed. Such calcifications occasion little, if any, neurological disturbance, and surgical treatment is rarely, if ever, required.

The series of cases of intervertebral disk protrusion under review in this paper were operated upon during the 21-year period 1938–1958, in the Department of Neurological Surgery of St. Bartholomew's Hospital. In *Table I* the number of surgically treated protrusions in the cervical, thoracic, and lumbar regions is shown. The youngest patient from whom a cervical disk protrusion was excised was a male aged 22 years, and the youngest patient with a thoracic protrusion a woman of 34 years. Experience

Table I.—SURGICALLY PROVEN INTERVERTEBRAL DISK PROTRUSIONS IN A 21-YEAR PERIOD

1. Cervical (11 median; 5 lateral)	16 cases
2. Thoracic (6—all median)	6 cases
3. Lumbar (median and lateral)	1,200 cases
Total	1,222 cases

* A paper given in July, 1959, at the combined meeting of the Canadian Neurological Society, the Association of British Neurologists, and the Society of British Neurological Surgeons.

with the disk protrusions of childhood and early adolescence has therefore been confined to those occurring in the lumbar region. Of the 1200 patients with surgically proven lumbar disk protrusions 38 (3·2 per cent) developed their symptoms at or before the age of 17 years. The records of these 38 patients have been analysed. This analysis will be contrasted with one previously made of a consecutive series of 500 patients, unselected as regards age, from whom lumbar disk protrusions were excised (O'Connell, 1951).

Age.—In *Table II* the number of patients developing symptoms during each year of age from 12 to 17 is shown. In the great majority of the patients symptoms were continuous from the age stated, but in 5 of the 38 in the series (3 girls and 2 boys) they were intermittent until persisting pain indicated surgical treatment.

Table II.—Onset of Symptoms at or before Age of 17 Years

Age	*Onset of Symptoms*	*Time of Operation*
12 yr. or less	2	—
13 years	2	—
14 ,,	5	—
15 ,,	7	4
16 ,,	13	7
17 ,,	9	7
18 ,,	—	7
19 ,,	—	10
20 ,,	—	3
Total	38	38

The table also indicates the age at which operation was performed in each of the 38 patients and demonstrates that symptoms arising in childhood and early adolescence may persist for long periods. It is considered that the age of onset of symptoms is more relevant to the discussion than is that at which operation was performed.

Sex.—Of the 38 patients, 16 (42 per cent) were females and 22 (58 per cent) males. This sex incidence differs from that in the previously reviewed group of 500 patients unselected as regards age, in whom only 33 per cent were women and 66 per cent were men. This increased proportion of female patients is due to a reversal of the usual sex incidence during the earlier years of the age range under consideration (*Table III*). Thus of the 16 patients developing symptoms while under the age of 16 years, 9 were girls and 7 boys, while in the 22 cases developing symptoms after 16 years and before 18 years, 7 were girls and 15 boys.

Table III.—Sex Incidence in Patients under and over Age of 16 Years

Sex	*Age under 16 yr.*	*Age over 16 yr.*
Female: 16 cases (42 per cent)	9 cases	7 cases
Male: 22 cases (58 per cent)	7 cases	15 cases
Total: 38 cases (100 per cent)	16 cases	22 cases

In series of 500 consecutive proven cases of Lumbar Disk Protrusion, females made up 33 per cent and males 66 per cent.

In seeking the explanation of this reversal of the usual sex incidence in patients below the age of 16 years, the time of occurrence of the rapid increases both in weight and height which characterizes puberty in both sexes is of interest. In *Fig.* 620 the annual increments in weight and height occurring in the two sexes between the ages of 5 and 19 years is shown, graphically. The figures for these increments are taken from the tables of Barach (1949). In the female the period of rapid weight increase extends from 11 until 15 years of age, the peak being during the twelfth year. In the male the corresponding period of weight increase extends from 11 until 17 years of age, the highest rate of increase being maintained from 13 until 16 years. Turning to the period of augmented growth in height in the female, this extends from 9 years to 14 years, and in the male from 9 years until 16 years. The periods of augmented growth in both weight and height thus occur earlier and are of shorter duration in the female than in the male. In the female the rate of growth falls rapidly after the age of 14 years, whereas in the male it is maintained until after the age of 16 years. It may well be that stresses developed in the low back during the period of rapid growth may be of aetiological significance in the development of lumbar disk protrusions, and if so, stress will develop later in the male than in the female. Possibly herein lies the explanation of the marked preponderance of girls in series of proven lumbar disk protrusions occurring in patients under the age of 16 years.

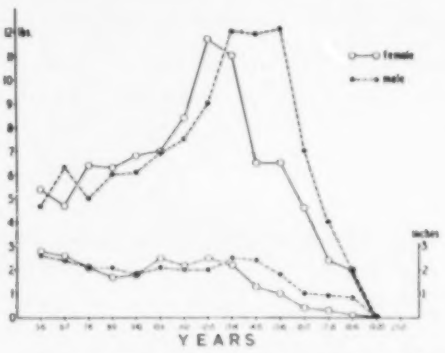


Fig. 620.—Graph comparing annual increments in weight and height in males and females between the ages of 5 and 20 years.

Aetiology.—The aetiological factors which appear important in the development of lumbar disk protrusions in the 38 patients of the series are set out in *Table IV*. Trauma in one form or another was thought to have been significant in 66 per cent—a figure which corresponds quite well with that in the previously reviewed group of 500 cases. In 10 per cent of the series it was believed that muscular

Table IV.—Aetiological Factors

1. *Trauma*:—		
Back strain	10	
Direct injury	9	
Occupational stress	6	
		25 cases (66 per cent)
2. *Relative Muscular Inadequacy*:—		
Excessive weight	1	
Excessive height	1	
Convalescence from illness or operation	2	
		4 cases (11 per cent)
3. *None Apparent*		9 cases (23 per cent)
		Total: 38 cases

inadequacy, either absolute during convalescence after a period of bed rest, or relative in exceptionally obese or tall patients, was significant. In 24 per cent of the cases no aetiological factor was apparent. As has just been indicated, it seems possible that the period of rapid growth in adolescence may in itself provide the stress which occasions a disk protrusion.

Symptoms.—In the younger patients, as in the cases of those of other age-groups, the outstanding symptom of a lumbar disk protrusion is pain. Some

Table V.—Distribution and Side of Pain

Lumbar and crural pain: 30 patients (79 per cent)
Crural pain alone: 8 patients (21 per cent)

	Side involved 38 *Patients of 17 yr. or under*	500 *Patients of all Age-groups*
Left leg	23 patients (61 per cent)	52 per cent
Right leg	13 patients (34 per cent)	39 per cent
Bilateral	2 patients (5 per cent)	9 per cent
Total	38 patients (100 per cent)	100 per cent

suggest that this pain in children is less than in older patients. The signs upon which the severity of the pain in these cases can be assessed do not support this view. It may well be that in children the emotional accompaniment of pain is less developed and that as a result of this they complain less than do adults.

In four-fifths of the patients the pain involved the low back and posterior crural areas together, while in the remaining one-fifth it was confined to the lower limb (*Table V*). In 61 per cent of the group, crural pain was left-sided and in 34 per cent right-sided, being bilateral in 5 per cent. It will be seen that this left-side preponderance was also present in

Table VI.—Incidence of Symptoms other than Pain

1. Paræsthesiæ in territory of affected roots	19 cases (53 per cent)
2. Subjective loss of power	5 cases (13 per cent)
3. Minor disturbances of vesical control	3 cases (8 per cent)

Incidence of Subjective Disability occasioned by a Neurological Deficit	
Patients of 17 yr. and under	0
Series of 500 patients of all age-groups	4 per cent

the series of 500 patients whose ages were distributed throughout the whole range. Symptoms other than pain, apart from paræsthesiæ in the distribution of the affected spinal nerve-roots, were relatively uncommon (*Table VI*). In particular, the severe functional

Table VII.—Duration of Attack of Pain preceding Operation

	38 *Patients with Symptoms commencing at or before 17 yr.*	500 *Patients of all Age-groups*
6 months or less	8 patients (21 per cent)	45 per cent
7–12 months	7 patients (18 per cent)	28 per cent
1–2 years	12 patients	
2–3 years	9 patients } 23 (61 per cent)	27 per cent
Over 3 years	2 patients	
Incidence of Multiple Attacks of Pain:—		
3 attacks: over periods of 3, 4, and 8 years		3 patients
2 attacks: over periods of 1, 2½, and 10 years		3 patients
	Total	6 (15 per cent)

(In the series of 500 consecutive proven cases of lumbar disk protrusion, 50 per cent had had multiple attacks.)

deficit which was seen in 4 per cent of patients in the larger series was not encountered in the younger group.

The duration of the attack of pain leading to operation was greater in the younger group of patients, being over 12 months in 61 per cent, against only 27 per cent in the larger group (*Table VII*). It would thus seem that when disk protrusions occasion severe symptoms in adolescence, healing may be long delayed. At this age a disk protrusion is frequently made up of soft elastic disk tissue with a high fluid content; moreover, its ligamentous covering is frequently intact. These pathological characteristics may explain the retarded healing. Multiple attacks of pain were less common in the younger group of patients, 15 per cent as compared with 50 per cent. This is due essentially to the tendency for symptoms to be more persistent in the young patients. Where healing of the lesion does occur and symptoms disappear, the possibility of further attacks of low back and sciatic pain of course exists as it does in adults. However, the patients will usually have passed out of the age-group now under review before such recurrence takes place.

Physical Signs.—These may be grouped under the headings spinal, tension, and neurological signs. The spinal and tension signs are indicated in *Table VIII*. As regards the former, the degree of reduction

Table VIII.—The Pre-operative Spinal and Tension Signs

1. *Limitation of Flexion*:—	
Recorded in 90 per cent and gross in	20 patients (53 per cent)
2. *Local Tenderness*	25 patients (66 per cent)
3. *Deformity*:—	
a, Reduced lordosis or kyphosis	36 patients (95 per cent)
b, Scoliosis	16 patients (42 per cent)
Tension Signs	
Very severe: S.L.R. $<45°$	32 patients (84 per cent)
Moderate: S.L.R. $45–70°$	5 patients (13 per cent)
Mild: S.L.R. $>75°$	1 patient (3 per cent)

of spinal flexion and the frequency of occurrence of a lumbar kyphosis was considerably greater in the group of young patients than in that previously reviewed. Again, in the young patients the reduction

Table IX.—The Pre-operative Neurological Signs

Signs	38 Patients of Series	500 Patients of all Age-groups
Motor		
Atrophy and hypotonia of posterior crural muscles	25 (66 per cent)	95 per cent
Weakness of toe movement	24 (63 per cent)	74 per cent
Weakness of ankle ± proximal movements	7 (18 per cent)	?
Nil	6 (16 per cent)	4 per cent
Sensation		
Reduction in one or more dermatomes	18 (47 per cent)	79 per cent
Hyperæsthesia in one or more dermatomes	1 (3 per cent)	1 per cent
Nil	19 (50 per cent)	20 per cent
Reflexes		
Absence of tendon reflex	5 (13 per cent)	78 per cent
Reduction of tendon reflex	19 (50 per cent)	
Nil	14 (37 per cent)	22 per cent

in straight-leg raising was in general very much more marked than in the older ones—the angle permitted on the side of the crural pain being less than 45° in 84 per cent of the group. Turning to the neurological signs (*Table IX*) it is clear that in the younger patients motor, sensory, and reflex abnormality was absent more often than in older ones. Moreover,

when the neurological abnormality was present in the adolescent it tended to be less severe than in the adult.

Radiological Findings.—Definite radiological change indicating the presence of a disk protrusion, narrowing of an intervertebral interval with or without lipping of the vertebral margins adjacent to this interval, was seen in only one-fifth of the patients, there being doubtful changes in a further one-third of the group (*Table X*). In almost half of the patients

Table X.—RADIOLOGICAL FINDINGS

	37 Patients with Symptoms arising at or before 17 yr.	*469 Patients of all Age-groups*
Changes indicating disk protrusion	8 cases (22 per cent)	57 per cent
Changes suggesting possibility	12 cases (32 per cent)	18 per cent
No relevant changes	17 cases (46 per cent)	25 per cent
Disk Narrowing:—		
Definite 8 cases	Possibly present	10 cases
Lipping of Vertebræ at Affected Level:—		
Definite 1 case	Possibly present	2 cases
Congenital Lumbosacral Spinal Anomalies: 11 cases (30 per cent)		

no changes indicative of a disk protrusion were present. The table indicates that radiological abnormality of diagnostic assistance was considerably more common in the larger series of patients drawn from all age-groups.

Congenital anomalies of the lumbar spine were revealed in 11 cases (30 per cent). Sacralization of the fifth lumbar vertebra was present in 5 of these, lumbarization of the first sacral vertebra in 1, spondylolysis in 1, and in 2 what has been described as 'occult sacralization' (Andrew, 1954). It is possible that at times such structural abnormalities may render the vertebral column less fitted to withstand stress and predispose to the development of disk protrusions.

Doubtless as a result of diagnostic uncertainty lumbar puncture and myelography were carried out in 26 per cent of the group of young patients and in only 8 per cent of the larger series unselected as regards age. The cerebrospinal fluid protein concentration was above 40 mg. per cent in half of these patients and the myelographic findings pointed definitely to a disk protrusion in 6 patients, being doubtful in 4.

Differential Diagnosis.—A clinical picture very similar to that of a lumbar disk protrusion may be produced both by other lesions within the lower portion of the spinal canal and by those affecting the lumbosacral portion of the spinal column.

1. *Lesions within the Spinal Canal.*—Of the intraspinal lesions in the young a neoplasm has been the common one. The history has frequently been long (up to 6 years) and in several patients symptoms have commenced in the first decade; a history of trauma has been rare and one of being wakened from sleep by nocturnal pain extremely common. Bilateral crural symptoms or signs were common. While the spinal and tension signs were frequently as severe as in cases of disk protrusions, the neurological ones were more marked in the presence of neoplasms compressing the cauda equina. Radiological signs of a tumour may be found and the diagnosis is settled by means of lumbar puncture and myelography.

One patient, a girl of 14 years with a clinical picture indicative of a disk protrusion, was found to have an intraspinal meningocele of the sheath of the first sacral nerve, and was considerably relieved by its excision. As in the case of several similar lesions in older patients, the picture may closely resemble that of a lumbar disk protrusion. These meningeal cysts will frequently be recognized only during the operative approach to a suspected disk protrusion, but the history of a marked increase in pain upon any activity which raises cerebrospinal fluid pressure and its immediate disappearance upon lying down may suggest the diagnosis, particularly if X-ray examination reveals erosion of the related vertebral body.

2. *Lesions of the Spinal Column.*—Of the lesions of the vertebral column which may suggest the diagnosis of a lumbar disk protrusion, spondylolisthesis occasions an identical clinical picture and was indeed associated with a disk protrusion at the affected level in 1 patient, a boy whose symptoms developed at the age of 15 years. Radiological examination will establish the diagnosis in every case. A different spinal lesion was present in another patient, a boy of 14 years who exhibited the clinical picture of a disk protrusion apart from a unilateral high lumbar tenderness. Operation revealed no disk abnormality, but an arthritis of the apophysial joint between the second and third lumbar vertebræ on the right side. Following excision of the medial articular surface of the joint a complete recovery followed with no recurrence over a 7-year period of post-operative observation. While early in our experience with lumbar disk protrusions the diagnosis of tuberculous spondylitis was frequently suspected in the adolescent patient, no case of this type has in fact been encountered. However, ankylosing spondylitis has occasioned difficulty. Thus, 1 patient with typical signs in the spine and well-marked limitation of straight-leg raising, though no neurological abnormality, was diagnosed as a lumbar disk protrusion and treated conservatively with improvement. Some years later symptoms returned and radiological examination showed the typical picture of ankylosing spondylitis. Further, one patient in the series of surgically treated disk protrusion, a boy of 16 years, was thought to have a small lateral protrusion of the penultimate disk. He was well for a year after its excision, when low back pain recurred and was followed by loss of weight, a raised E.S.R., and the typical radiological signs of ankylosing spondylitis. While it has been suggested that radicular pain in ankylosing spondylitis may be due to disk protrusions, it is clear that if there is evidence to suggest the presence of the diffuse joint disease, operative treatment for a disk protrusion should be avoided.

Table XI.—OPERATIVE FINDINGS

Last intervertebral disk		L.5–S.1: 14			
	True	L.4–5: 5	19 cases	(50 per cent)	
Penultimate intervertebral disk		L.4–5: 16			
	True	L.3–4: 1	17 cases	(45 per cent)	
Both disks:		2	2 cases	(5 per cent)	
		Total	38 cases	(100 per cent)	

(In a consecutive series of 500 cases the last interval was involved in 60 per cent and the penultimate interval in 30 per cent.)

Findings at Operation.—The protrusion occurred at the last intervertebral joint in 50 per cent

of the patients and at the penultimate joint in 45 per cent (*Table XI*). In 2 cases (5 per cent) the disks at both levels had protruded. The level of the protrusion is thus described since in cases of sacralization of the fifth lumbar vertebra the last interval is not, in fact, lumbosacral but that between the fourth and fifth lumbar vertebræ. Moreover, where sacralization is present, a protrusion of the penultimate disk actually involves the joint between the third and fourth lumbar vertebræ.

The picture revealed at operation did not differ from that seen in older patients, symptoms being due to compression or stretching of, in particular, the extradural intraspinal nerve, or to a combination of the two factors. Lipping of the vertebral margins was uncommon. The disk tissue excised frequently appeared to contain more fluid than is the case in adults. In 35 patients the average weight of the specimen removed at operation, prior to its immersion in fixative, was 3·4 g. This is larger than the average specimen removed in adults, since in 350 patients, unselected as regards age, the weight of tissue excised averaged less than 3 g. in 77 per cent.

Post-operative Course.—An immediate symptomatic improvement and increase in mobility occurred in all cases, and the most common post-operative complication was occasional transient retention of urine. In 2 patients a pre-operative motor deficit increased after surgery. One of these, a boy of 15 years, had bilateral crural pain and a well-marked reduction of power in the muscles of the left lower limb below those supplied by the fourth lumbar segment. Myelography revealed a complete block at the penultimate disk level. A bilateral exposure was made and the partly calcified protrusion excised. Post-operatively weakness of the right leg, especially peripherally, was present. This, together with the left-sided weakness, had largely disappeared in 3 months. The second patient, a boy of 16 years, had a protrusion of the penultimate disk on the left side and remained well for 7 years following its excision. He then developed right crural pain and a protrusion of the same disk, but on the right side, was excised. Following operation, weakness of the right lower limb appeared. This cleared slowly but completely over a period of 18 months.

Results of Operative Treatment.—Three patients have not been seen or traced since their discharge from hospital. The duration of the period of post-operative observation in the remaining 35 patients is shown in *Table XII*. The effect of operation upon the patient's symptoms is indicated in

Table XII.—Duration of Post-operative Observation in 35 Patients

Over 10 years	6 patients	(17 per cent)
5–10 years	3 patients	(9 per cent)
2–5 years	8 patients	(23 per cent)
1–2 years	6 patients	(17 per cent)
7–12 months	6 patients	(17 per cent)
3–6 months	6 patients	(17 per cent)
Total	35 patients	(100 per cent)

Table XIII. Over half of the patients had no symptoms referable to the disk lesion. Crural pain was completely relieved in 80 per cent, but recurred transiently with greater or less severity in 20 per cent. Back pain was absent in 71 per cent and occurred, usually as the result of strain, in 29 per cent.

The patients' own assessment of the value of operative treatment is indicated in *Table XIV*. It will be seen that 91 per cent of the patients considered

Table XIII.—Results of Operative Treatment in 35 Patients

Symptoms:—			
No Symptoms referable to Disk Lesion			20 (57 per cent)
Lower Limb Pain:			
Absent			28 (80 per cent)
Present	Transient and mild with minimal signs	4	7 (20 per cent)
	Transient but more severe with signs	3	
Back Pain:			
Absent			25 (71 per cent)
Present	Transient or recurring: following strain		10 (29 per cent)

themselves either cured or greatly improved. These results are somewhat better than those in the group of 500 patients of all age-groups previously reviewed. The incidence of recurrence and re-operation (6 per cent) is, however, greater than it was in the larger series (2·3 per cent).

Table XIV.—Subjective Assessment of Results in 35 Patients

Cured	22 patients	(63 per cent)
Much improved	10 patients	(28 per cent)
Recurrence and re-operation	2 patients	(6 per cent)
Recurrence (ankylosing spondylitis)	1 patient	(3 per cent)

In *Table XV* the residual physical signs at the latest examination in the 33 patients who attended for one or more such examination after operation are shown. As in older patients the spinal and tension signs were both mild and infrequent. The mild

Table XV.—Residual Physical Signs in 33 Patients in whom Examination performed

1. *Spinal*:—			
	Deformity	2	5 patients (15 per cent)
	Minor reduction in mobility	3	
2. *Tension*:—			
	Reduction of S.L.R.		6 patients (18 per cent)
3. *Neurological*:—			
Motor:—			
	Muscular hypotonia	3	
	Muscular weakness (toe movement in 4)	5	6 patients (18 per cent)
Sensation:—			
	Dermatome reduction		6 patients (18 per cent)
Reflex:—			
	Absent ankle-jerk	11	22 patients (64 per cent)
	Reduced ankle-jerk	10	
	Reduced knee-jerk	1	

motor and sensory abnormalities present post-operatively in large measure disappeared. On the contrary, as has previously been noted in adults, reflex abnormality present pre-operatively frequently persists.

DISCUSSION

In the diagnosis of lumbar intervertebral disk protrusions in children an awareness of their occurrence in this age-group is the first requisite. While the clinical picture is very similar to that in adults, it must be recognized that in adolescents severe spinal and tension signs may occur without any associated neurological abnormality. Moreover the frequent absence of radiological abnormality in the lumbar

spine in adolescents must not be regarded as weighing against the diagnosis of a disk protrusion. Myelography can provide valuable diagnostic assistance in difficult cases.

The reason why disk protrusions produce somewhat different clinical pictures in adolescents and adults deserves consideration. It has previously been suggested (O'Connell, 1943) that spinal signs—deformity and reduced mobility—and tension signs—in particular reduction of straight-leg raising—are designed to protect the affected extradural nerve from forces which stretch or compress it, whereas the abnormal neurological signs are the result of injury to this nerve and are a measure of the failure of the protective mechanism. It is believed that two factors influence the severity of the spinal and tension signs. The first of these is hyperirritability of the extradural nerve. It has frequently been found during operations upon lumbar disk protrusions that even gentle manipulation of the nerve to expose the protrusion occasions muscle twitching in the affected lower limb, whereas retraction of the nerve at a level where there is no abnormality occasions no such muscular contraction. Moreover, in cases with severe neurological signs this irritability of the extradural nerve is lost, no doubt because of injury to its constituent nerve-fibres. It is possible that the hyperirritability of the affected nerve secondary to minor injury is greater in children than in adults and exaggerates the protective spinal and tension signs. The second factor influencing the severity of these signs is the degree of tension in or compression of the affected nerve. These depend upon several factors, but in particular upon the size of the protrusion. It might be expected that they would be exaggerated in the presence of the large soft protrusions which are frequently found in adolescence. The combination of a hyperirritable extradural nerve and a large soft protrusion might be expected to induce marked muscle spasm. In the mobile spine of early life severe deformity and limitation of mobility may thus be produced and the efficient protection of the nerve which they occasion lead to a reduction in the neurological signs.

SUMMARY

1. The records of 38 patients under the age of 18 years in whom the presence of lumbar intervertebral disk protrusions was surgically demonstrated are reviewed and compared with those of a group of 500 cases of all age-groups.

2. The aetiology of disk protrusions in childhood and adolescence is discussed and it is suggested that stresses occasioned by the period of rapid growth may be a factor of some importance.

3. The symptomatology resembles that in adults. The young patients may complain less although their symptoms may be very persistent. In no case did a severe defect of function arise.

4. The spinal signs and those of tension in the roots of the sciatic nerve are frequently more severe than in adults whereas abnormal neurological signs are less common and less severe in adolescents.

5. Radiological abnormality in the lumbosacral region is frequently absent.

6. The differential diagnosis is discussed.

7. The operative findings are described and the results of surgical therapy evaluated.

8. An explanation for the differences in the clinical pictures produced by lumbar disk protrusions in adolescence and in adult life is put forward.

REFERENCES

ANDREW, J. (1954), *Brit. J. Surg.*, **42**, 304.
BARACH, J. H. (1949), *Diabetes and its Treatment*, 207. New York: Oxford University Press.
BJELKHAGEN, J., and GLADNIKOFF, H. (1957), *Acta radiol. scand.*, **48**, 51.
FERNSTROM, V. (1956), *Acta chir. scand.*, **111**, 71.
KEY, J. A. (1950), *J. Bone Jt Surg.*, **32a**, 97.
O'CONNELL, J. E. A. (1943), *Brit. J. Surg.*, **30**, 315.
— — (1951), *J. Bone Jt Surg.*, **33b**, 8.
WAHREN, H. (1945), *Acta orthop. scand.*, **16**, 40.
WALKER, C. S. (1954), *J. Bone Jt Surg.*, **36b**, 601.
WEBB, J. H., SVIEN, H. J., and KENNEDY, R. L. J. (1954), *J. Amer. med. Ass.*, **154**, 1153.

EXTENDED RIGHT HEMICOLECTOMY

THE TREATMENT OF ADVANCED CARCINOMA OF THE HEPATIC FLEXURE AND MALIGNANT DUODENOCOLIC FISTULA

By H. W. GALLAGHER

BANBRIDGE HOSPITAL, BANBRIDGE, CO. DOWN

THE treatment of carcinoma of the hepatic flexure, not involving other structures, is standardized. Once fixation to, and involvement of, surrounding structures has occurred courageous surgery is recommended by Raven (1947), Lloyd-Davies, Morgan, and Goligher (1953), and Prohaska, Nelsen, and Evans (1956), but unless there is a preconceived plan it is easy to declare that such a lesion is incurable and perform a palliative operation. The purpose of this communication is to describe right hemicolectomy and pancreatoduodenectomy as a one-stage procedure which can be used as a basis on which the treatment of advanced cases can be planned. It has been named 'extended right hemicolectomy'.

INCIDENCE OF INFILTRATION OF DUODENUM AND HEAD OF PANCREAS

Carcinoma of the hepatic flexure is uncommon. Boehme and Hanson (1946) found an incidence of only 2·94 per cent in 1497 cases of carcinoma of the

colon. Therefore no individual surgeon can expect to deal with many cases and no personal series has been published.

Phillips, Dockerty, and Waugh (1955) reviewed 136 cases seen in the Mayo Clinic in 40 years. In 47 patients (37 per cent of 127 operations) fixation of the primary to contiguous organs was noted. The duodenum was involved in 24 cases, gall-bladder 10, stomach and pancreas each in 7, and other organs less frequently. In some patients more than one organ was involved, therefore the frequency of involvement of duodenum and/or pancreas lay between 19 and 24 per cent.

Bertrand and Gilbertas (1956) report a personal series of 71 cases of carcinoma of the right colon of which 32 involved the flexure. Palliative operations were performed in 24 per cent of cases, presumably because of local fixation, but unfortunately no indication is given of the frequency of involvement of duodenum and pancreas from carcinoma of the hepatic flexure. It is unlikely to be less than 20 per cent.

During the last 12 years only 8 cases of carcinoma of the hepatic flexure have been treated in Banbridge Hospital. This represents just over 6 per cent of all cases of carcinoma of the large bowel treated during that time. In only 2 cases was the duodenum not involved and in only 1 case was the growth confined to the colon. This was the only one suitable for standard right hemicolectomy and he remains well after 18 months. In 2 others right hemicolectomy was performed with difficulty because of gross fixation to duodenum and pancreas. Adherent duodenal muscle wall was excised in one of them, who survived 3 years and then developed local recurrence. The other patient had local recurrence within a few months.

In 2 patients the growth was too advanced even for extended right hemicolectomy and palliative ileotransverse colostomy was performed. One patient whose growth was infiltrating the anterior abdominal wall had a segment of parietal peritoneum and transversalis fascia excised in continuity with the tumour. He remains well after 3 years. The 2 remaining patients had 'extended right hemicolectomy'. In one of these the growth had caused a duodenocolic fistula.

The 2 cases in which the growth was very adherent to the duodenum and pancreas and in which hemicolectomy was performed seem to illustrate Phillips and others' (1955) findings that fixation is due in 50 per cent of cases to inflammation rather than to infiltration. At operation it is impossible to differentiate between inflammation and infiltration, and the guiding principle should be to remove all possibly invaded structures, if such a procedure is feasible.

Eight cases are too few on which to dogmatize, but the high incidence of infiltration of the duodenum and head of the pancreas suggests that extended right hemicolectomy should become a standard operation which would be used not infrequently in the treatment of advanced carcinoma of the hepatic flexure and also in carcinoma of the head of pancreas if the colon is invaded.

MALIGNANT DUODENOCOLIC FISTULA

Perforation of the growth into the duodenum, giving a malignant duodenocolic fistula, is a very serious complication of fixation to the duodenum. In the absence of treatment, and in many instances in spite of treatment, these cases are rapidly fatal and so rarely is treatment curative that even recovery from operation has, in the past, been sufficient grounds for publication.

The main line of treatment has been right hemicolectomy with local removal of involved duodenal wall together with other involved organs such as pyloric antrum, gall-bladder, etc. The mortality-rate for this operation is high, mainly because of difficulty in closure of the duodenal defect. Calmenson and Black (1947), Garland and Wyatt (1951), Carnot and Caroli (quoted by Bucaille, 1952), and Boulouys, Levère, and Bruschet (1953) all report operative deaths. Calmenson and Black (1947), Drake and Goodwin (1948), Kredel (1951), Baker (1952), Welti (1952), Lortat-Jacob (1952), Delannoy, Gautier, Devambez, and Toison (1954), Fontaine, Warter, Frank, and Schuler (1955), and Raffensberger, Sylvester, and Ferguson (1957) are among those who report successful cases. The long-term results in these cases were not good and only 1 patient appears to have survived for longer than 6 months (in some cases no post-operative history is given). Patterson (1957) sums up this collective experience: "Simple local excision of the obviously involved area of the duodenal wall gives extremely poor results."

The case reported by Kredel (1951) is remarkable in that 2 years and 6 months prior to right hemicolectomy together with partial gastrectomy and local removal of involved duodenum, another surgeon had performed cæcostomy for an "inoperable" tumour of the hepatic flexure. In spite of this delay the patient was alive and showed no sign of recurrence 22 months later. This long period of survival illustrates "the incomputable factor in cancer prognosis" (Gordon-Taylor, 1959) and shows that even in apparently hopeless cases radical resection may achieve unexpected relief and apparent cure.

Linton (1944) was the first to suggest a more radical approach to the problem of fistula and, following the 'Whipple' technique, he performed pancreatoduodenectomy with right hemicolectomy as a multi-stage procedure in 2 cases. Prohaska and others (1956) report 1 case of duodenocolic fistula and 1 case of carcinoma of the head of pancreas infiltrating the colon in which pancreatoduodenectomy and right hemicolectomy were performed. No operative details are given.

The effects of duodenocolic fistula are similar to those of gastrocolic and gastrojejunocolic fistula in which single-stage operation is now recommended by Illingworth and Kay (1957) and Marshall and Knud-Hansen (1957). Linton (1944) did not think that a one-stage procedure would be possible in duodenocolic fistula, but the advances in therapy which have made single-stage procedures possible in other internal fistulæ also apply to it. Right hemicolectomy together with pancreatoduodenectomy is the rational radical approach to the problem of treatment.

EXTENDED RIGHT HEMICOLECTOMY

Delannoy and others (1954) describe their patient as having had "extended right hemicolectomy"—"hémi-colectomie droite élargée". This consisted of

right hemicolectomy, local resection of duodenal wall, cholecystectomy, and diathermy dissection of part of pancreas without interference with biliary or pancreatic ducts. It is suggested that it would be better to keep the term confined to the more radical procedure of right hemicolectomy together with pancreatoduodenectomy.

OPERATIVE PROCEDURE

The operation is a marriage between right hemicolectomy and pancreatoduodenectomy, both of which are standard procedures. Cattell and Warren (1953) and Smith (1956, 1958) have blazed a trail in the surgery of the pancreas along which the average

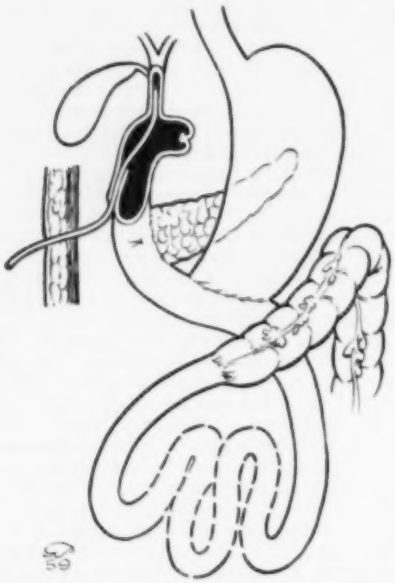


FIG. 621.—Reconstruction recommended after extended right hemicolectomy.

abdominal surgeon can travel with confidence and only the steps peculiar to the combined operation will be indicated. The main difficulty is in deciding whether or not the operation is possible and the point-of-no-return must be postponed as long as possible.

A long right paramedian incision with adequate relaxation gives adequate exposure and is probably preferable to an oblique or transverse approach. Once fixation to duodenum and/or head of the pancreas has been demonstrated, the right colon and duodenum should be mobilized from the posterior abdominal wall as in the first stages of both 'parent' operations. If the duodenum and pancreas can be lifted forward attention is diverted to the superior mesenteric artery, which should be exposed on the third part of the duodenum. This is probably the most difficult part of the operation. Glands or even the mass of growth and inflammatory reaction may extend right up to the origin of the mid-colic artery, but one should not be easily deterred from proceeding with the operation because the glands may be inflammatory and not malignant. The lesser sac is opened through the gastrocolic omentum and the origins of the mid-, right, and ileo-colic arteries are demonstrated. The common bile-duct is exposed, and the gastroduodenal and right gastric arteries are divided between ligatures to expose the portal vein. The pancreas is now separated from the superior mesenteric and portal veins in the usual manner and resectability demonstrated. The stomach is divided through the pyloric antrum or higher up if necessary. The common bile-duct is divided and held to one side. The mid-, right, and ileo-colic vessels are divided between ligatures and the transverse colon and the terminal ileum are divided. The jejunum is then divided just distal to the duodenojejunal flexure and the proximal jejunum is brought underneath the superior mesenteric vessels in the usual manner and the uncinate process of the pancreas divided. Division of the body of the pancreas allows removal of the specimen.

If the gall-bladder is involved, the decision as to resectability is very difficult. The first part of the duodenum cannot be exposed properly until the gall-bladder is mobilized from the liver and the cystic duct and artery are divided, and one does not feel justified in dividing these structures until resectability is proved. Gentle finger exploration in the region of the common bile-duct with elevation of the duodenum from the posterior abdominal wall may demonstrate resectability.

Reconstruction (*Fig.* 621).—The common bile-duct and the pancreatic ducts are small, making anastomosis difficult. The anastomosis of the common bile-duct to the side of the jejunum is done over a long 'Portex' tube which is brought out through a small tunnel in the side of the jejunum and through the abdominal wall (Bailie, 1959). It is removed after 10–14 days.

The pancreatic duct may be very difficult to find but should always be located and this anastomosis is performed over a short length of rubber tubing (Cattell and Warren, 1953; Smith, 1956). Alternatively the pancreatic duct is pulled through a stab incision in the jejunal mucosa and anchored by a silk stitch as in a 'Coffey' anastomosis of the ureter (Bailie, 1959). The stomach is anastomosed end-to-side to the jejunum and end-to-end anastomosis between the terminal ileum and the transverse colon completes the continuity of the intestinal tract. The abdomen is closed with drainage.

ILLUSTRATIVE CASES

Case 1.—R. S., male, born 1904. He had lost 5 st. in weight in one year and had had diarrhœa for two months prior to admission to Banbridge Hospital on July 22, 1957. On admission he weighed 10 st. 8 lb. X-ray screening following barium enema revealed a duodenocolic fistula, which was also demonstrated radiologically after a barium meal (*Figs.* 622–623).

On Aug. 13 operation under general anæsthesia was undertaken with the hope of doing a right hemicolectomy and limited resection of duodenum. However, the head of the pancreas was obviously infiltrated but there were no distant metastases. No satisfactory palliation short of radical surgery could be worked out and pancreatoduodenectomy with right hemicolectomy was performed. Separation of the neoplastic mass from the superior mesenteric

vessels required a tedious and meticulous dissection and the presence of enlarged glands behind the portal vein almost caused abandonment of the operation. The duodenum was divided at the superior mesenteric vessels and the distal end closed. Cholecystojejunostomy was performed and the common bile-duct was implanted in the side of the jejunum and because the pancreatic duct could not

FIG. 622.—*Case* 1. Barium enema of duodenocolic fistula. Filling of stomach and duodenum.

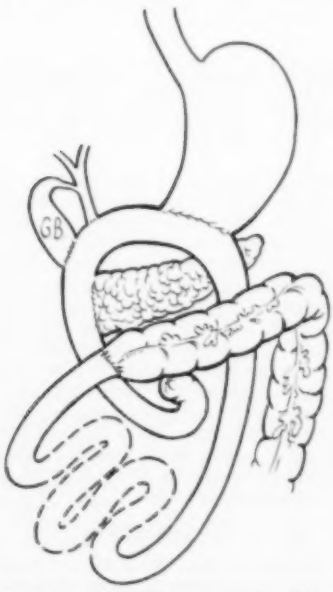


FIG. 624.—*Case* 1. Method of reconstruction after extended right hemicolectomy.

be found the full width of the pancreas was implanted in the side of the jejunum. Gastrojejunostomy and ileo-transverse colostomy completed the reconstruction (*Fig.* 624).

Post-operatively there was leakage of pancreatic juice for a few days, but his progress was uneventful. He was kept in hospital until he had regained his pre-operative weight and was discharged on Sept. 9.

FIG. 623.—*Case* 1. Barium meal of duodenocolic fistula showing site of fistula.

In April, 1960, his weight was 14 st. 2 lb., he felt perfectly well, and was working as a postman. There was nothing to suggest recurrence.

Case 2.—D. A., male, born 1905. He was admitted to Banbridge Hospital on Feb. 9, 1959, with a 2-year history of diarrhœa and 4 st. loss in weight. At one stage there had been a little blood and a little mucus in the stools. X-ray screening after barium enema revealed a carcinoma of the hepatic flexure.

The abdomen was explored under general anæsthesia on Feb. 17. There were no distant metastases, but infiltration of gall-bladder, duodenum, and pancreas was obvious. Extended right hemicolectomy with cholecystectomy was performed. The gall-bladder was very adherent to the liver, so a slice of liver was removed with the gall-bladder.

RECONSTRUCTION.—End-to-end anastomosis of the common bile-duct and jejunum was performed over a short rubber tube which was not anchored to the anastomosis. A similar technique was followed for the pancreatic duct and gastrojejunostomy and ileotransverse colostomy completed the operation (*Fig.* 625).

There was considerable bile drainage for 2 days but his post-operative course was uneventful and he was discharged home on March 4 on the fifteenth post-operative day. His pre-operative weight was 10 st. 12 lb.; on discharge it was 10 st. 6 lb., and on March 19 it was 11 st. 6 lb. On the latter date he was feeling extremely well.

SUBSEQUENT HISTORY.—On the evening of April 11 he was re-admitted, having had severe epigastric pain for a few hours, somewhat relieved by vomiting a couple of mouthfuls of bright red blood. Shortly after admission he vomited 1 oz. of dark blood. His abdomen moved freely with respiration and was not tender. During the night he had melæna on one occasion but his general condition remained good until 10 o'clock on the morning of April 12, when he had massive hæmatemesis which

became continuous. Massive transfusion was unavailing. He never became fit for operation, and he died at 1 p.m.

Post-mortem examination was performed on April 13 by Dr. Mitchell. There was intense hæmorrhagic gastritis with multiple erosions, acute ascending cholangitis, and the tube was still present in the anastomosis between the common bile-duct and jejunum. No malignant tissue could be demonstrated.

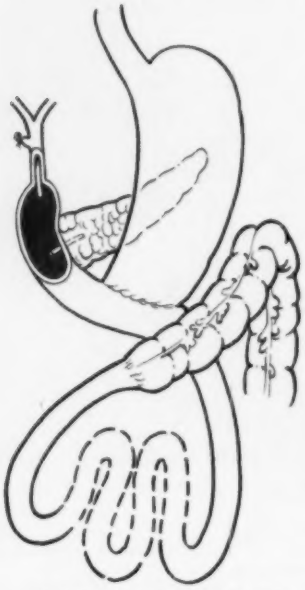


FIG. 625.—*Case* 2. Method of reconstruction after extended right hemicolectomy and cholecystectomy.

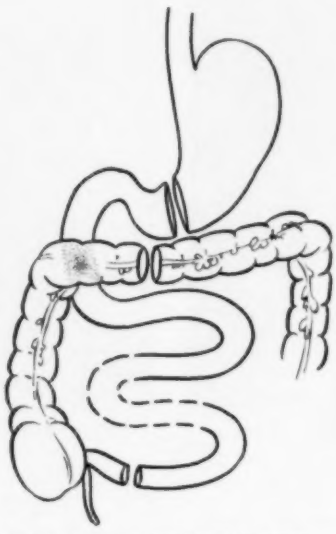


FIG. 626.—Suggested palliation for inoperable duodenocolic fistula. First stage.

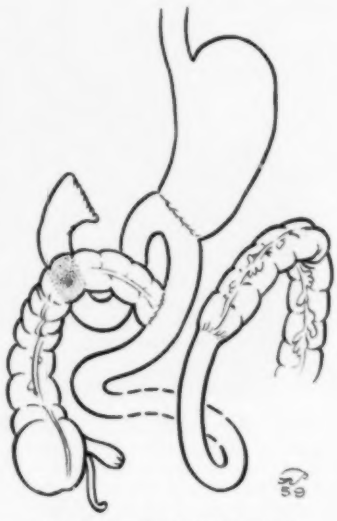


FIG. 627.—Suggested palliation for inoperable duodenocolic fistula. Second stage. If obstruction of the colon by the growth appears imminent then anastomosis between ascending colon and right transverse colon will also be required.

The failure of the tube to pass from the anastomosis must have been a factor in the aetiology of the cholangitis, which was very intense, and Dr. J. E. Morison, who reviewed the material both macroscopically and microscopically, is of the opinion that the gastritis was secondary to the cholangitis.

The only way of preventing a recurrence of such an unfortunate event is by making sure that the tubing is passed and for that reason the type of anastomosis introduced by Bailie (1959) is recommended. Of course, if the common bile-duct is dilated there would be no need to use a tube.

Cattell and Warren (1953) had only 2 cases of hepatitis or hepatic abscess in 102 cases of choledochojejunostomy performed over a tube, and the present author may be unfortunate in that the only case in which he has used this technique developed this complication. Provision for the sure removal of the tube seems to be a reasonable procedure.

No trouble due to non-passage of a tube at the anastomosis of the pancreatic duct has been reported and there does not seem to be any justification to depart from accepted technique. However, the 'Coffey' technique is reported by Bailie (1959) to work well and there is no risk of foreign body reaction.

PALLIATION OF INOPERABLE DUODENOCOLIC FISTULA

Palliation is very difficult. Raffensberger and others (1957) found that after end-to-side ileotransverse-colostomy diarrhœa continued, and Linton (1944) found that end-to-side ileotransverse-colostomy and end-to-side gastrojejunostomy were unsuccessful in 2 cases in providing palliation and the condition of the patients for the second stage was very little better than for the first stage. The persistence of diarrhœa, mal-absorption, and electrolyte loss is due either to reflux of colonic contents into the duodenum, causing an enteritis, or leakage of bile and pancreatic juice through the fistula into the colon.

Complete exclusion of the right colon would prevent reflux of fæcal material into the duodenum but the right colon would probably distend and eventually rupture. It is suggested that anastomosis of excluded right colon to jejunum below an exclusion gastrojejunostomy would overcome this difficulty.

Technique.—After deciding that the lesion cannot be removed, the pyloric antrum, transverse colon, and terminal ileum are divided (*Fig.* 626). The distal ends of the stomach and ileum are closed and gastrojejunostomy, ileotransverse-colostomy, and anastomosis between proximal transverse colon and jejunum are performed (*Fig.* 627). If obstruction of the colon by the growth appears to be imminent then anastomosis between the cæcum and proximal transverse colon would also be required.

SUMMARY

The duodenum and head of the pancreas are involved in a considerable number of cases of carcinoma of the hepatic flexure.

Malignant duodenocolic fistula is one variety of such extension.

Radical surgery in such cases is well worth while and it is suggested that pancreatoduodenectomy and

right hemicolectomy can be fused into one operation called 'extended right hemicolectomy'.

The difficulties in palliation of duodenocolic fistula are discussed and a procedure for palliation is suggested.

Acknowledgements.—I wish to thank Dr. W. F. K. Morrow for his help, encouragement, and anæsthetic skill which made the performance of these operations possible; Sister Groves and the nursing and resident medical staff in Banbridge Hospital, without whose unfailing skill and attention operations of such magnitude could not be performed; Dr. J. E. Morison and Dr. E. S. Mitchell for the post-mortem and pathological reports; Dr. T. N. Fogarty for the radiological reports; and Dr. Basil Jackson for help with translation from the foreign literature. I am also indebted to Mr. H. W. C. Bailie for permission to publish his method of choledocho- and pancreato-jejunostomy.

REFERENCES

BAILIE, H. W. C. (1959), personal communication.
BAKER, H. K. (1952), *J. Mo. med. Ass.*, **49**, 49.
BERTRAND, P., and GILBERTAS, A. (1956), *Arch. Mal. Appar. dig.*, **45**, 298.
BOEHME, E. J., and HANSON, P. J. (1946), *Surg. Clin. N. Amer.*, **26**, 551.
BOULOUYS, J., LEVÈRE, J., and BRUSCHET (1953), *J. Radiol. Électr.*, **34**, 260.
BUCAILLE, M. (1952), *Arch. Mal. Appar. dig.*, **41**, 643.
CALAENSON, M., and BLACK, B. M. (1947), *Surgery*, **21**, 476.
CATTELL, R. B., and WARREN, K. W. (1953), *Surgery of the Pancreas*, 326. Philadelphia and London: Saunders.
DELANNOY, E., GAUTIER, P., DEVAMBEZ, J., and TOISON, G. (1954), *Lille chir.*, **9**, 243.
DRAKE, E. P. H., and GOODWIN, G. F. (1948), *Brit. J. Surg.*, **36**, 204.
FONTAINE, R., WARTER, P., FRANK, P., and SCHULER, F. (1955), *J. Radiol. Électr.*, **36**, 704.
GARLAND, J. G., and WYATT, K., jun. (1951), *Rocky Mtn med. J.*, **48**, 4.
GORDON-TAYLOR, G. (1959), *Brit. med. J.*, **1**, 455.
ILLINGWORTH, C. F. W., and KAY, A. W. (1957), *Surgical Progress*, 66. London: Butterworth.
KREDEL, F. E. (1951), *Amer. Surg.*, **17**, 99.
LINTON, R. R. (1944), *Arch. Surg., Chicago*, **48**, 197.
LLOYD-DAVIS, O. V., MORGAN, C. N., and GOLIGHER, J. C. (1953), *Surgical Progress*, 72. London: Butterworth.
LORTAT-JACOB, J. L. (1952), *Arch. Mal. Appar. dig.*, **41**, 661.
MARSHALL, S. F., and KNUD-HANSEN, J. (1957), *Ann. Surg.*, **145**, 770.
PATTERSON, H. A. (1957), *Arch. Surg., Chicago*, **74**, 465.
PHILLIPS, J., DOCKERTY, M. B., and WAUGH, J. M. (1955), *Cancer, Philad.*, **8**, 151.
PROHASKA, J. V., NELSEN, T. S., and EVANS, S. O. (1956), *Arch. Surg., Chicago*, **73**, 671.
RAFFENSBERGER, E. C., SYLVESTER, L. E., and FERGUSON, L. K. (1957), *Ibid.*, **74**, 333.
RAVEN, R. W. (1947), *Brit. med. J.*, **2**, 249.
SMITH, RODNEY (1956), *Operative Surgery*, **2**, 279. London: Butterworth.
— — (1958), *Operative Surgery*, Progress Volume, 14. London: Butterworth.
WELTI, H. (1952), *Arch. Mal. Appar. dig.*, **41**, 689.

ADENOCARCINOMA OF THE APPENDIX

A REPORT OF TWO CASES

BY G. H. COOK

SURGICAL REGISTRAR, ST. ANTHONY'S HOSPITAL, CHEAM, SURREY

AND B. P. FLANNERY

SENIOR SURGICAL REGISTRAR, ST. HELIER HOSPITAL, CARSHALTON, SURREY

NEOPLASMS of the appendix are of three histological types: carcinoid tumours, malignant mucoceles, and adenocarcinomata.

Carcinoid Tumours are generally considered to be not true carcinomata. They are of variable malignancy (Burton, 1947) and typically occur in the appendix and small intestine. In the appendix they are usually readily recognizable macroscopically as a firm nodule, usually in the distal third, which on cross-section appears as a yellow ring encircling the appendix and situated in the thickened submucous coat. They commonly produce no symptoms and are discovered after the appendix has been removed.

These tumours may secrete 5-hydroxytryptamine (serotonin), and the detection of its metabolic breakdown product, 5-hydroxy indole acetic acid, in more than trace amounts in the urine is said to be diagnostic not only of the presence of the tumour, but of its metastases in the liver.

Malignant Mucocele of the appendix is still a controversial entity (Willis, 1948). It has been described as a mucous secreting carcinoma which, with intraluminal growth and obstruction, leads to distension of the organ, vascular stasis within its wall, secondary infection, and eventual rupture. The latter event is commonly accepted as the cause of pseudomyxoma peritoneii.

Adenocarcinoma is the most malignant of the three types. It is the least common neoplasm of the appendix, only about 85 cases having been reported to date in the British, American, Canadian, Australasian, and South African literature. In 144 cases collected by Uihlein and McDonald (1943) it represented only about 3·5 per cent of the total; carcinoids accounting for 88·2 per cent and malignant mucocele for 8·3 per cent. Its incidence has been indicated in another way by Niceberg, Feldman, and Mandelberg (1956), who found 1 case in 2301 appendicectomies.

The following cases are of interest not only because of the rarity of the lesion, but because one case presented an unusual clinical picture and the other one occurred in an appendix with an abnormal mucosa of the type reported by Ashley (1958).

CASE REPORTS

Case 1.—Mr. W., a 58-year-old white male, was first seen as an out-patient on Sept. 30, 1958. He complained of pain in his right loin. It had been present for two months and he associated it with an injury to that region some months previously. He had no other symptoms except that he had to get up once each night to pass urine. His weight had been increasing slightly.

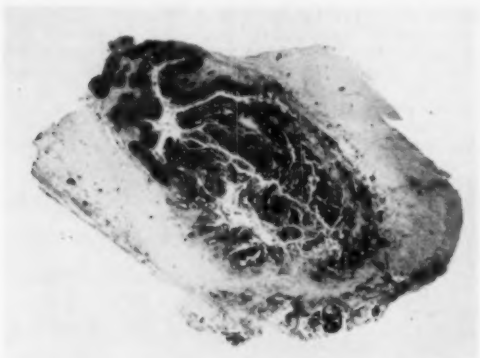


FIG. 628. *Case* 1.—Adenocarcinoma of the appendix. The growth extends beyond the wall of the appendix. H. and E. (× 10.)

The only abnormal physical finding at that time was slight tenderness in the right iliac fossa.

He was next seen three weeks later, at which time he had a firm, inflammatory swelling just above the middle third of his right iliac crest. An intravenous pyelogram had shown no abnormality apart from a bifid right kidney which appeared to be functioning normally. His urine was acid and sterile, his white-cell count was 6000 per cu.mm. and erythrocyte sedimentation rate was 25 mm./200 in one hour (Westergren). A radiograph of his pelvis did not show any bony lesion.

He was admitted to St. Helier Hospital on Oct. 28 and a fluctuant mass was drained of 30 ml. of white pus on Oct. 29. Culture of the pus both aerobically and anaerobically produced only coliform bacilli. A Ziel-Neilsen stain showed no evidence of mycobacterian tuberculosis. Gram stain showed occasional Gram-positive cocci and a large number of pus cells. Lowenstein culture was set up: this was subsequently reported to be negative.

His general condition remained excellent; his wound stopped draining and was healed in one week. He was discharged from hospital on Nov. 5 and a barium enema was arranged as an out-patient. In this examination the colon appeared to be normal but the cæcum was not filled and no barium entered the ileum. A barium trace one week later showed a normal pattern for the ileum and showed the cæcum and ascending colon to be lying high in the abdomen, but no other abnormality was detected. The appendix had not filled in either of these examinations.

He was re-admitted on Feb. 26, 1959, with recurrence of a painful abscess at the same site in his right loin. On this occasion he was found to have an extensive, loculated cavity extending retroperitoneally to a depth of 3 in. (7·5 cm.). A large amount of pus and necrotic tissue was removed and culture produced a growth of *B. coli*. In an histological examination clusters of atypical columnar cells were seen in a mass of chronic, pyogenic granulation tissue. These were regarded by the pathologist as almost certainly adenocarcinoma.

The patient was prepared for laparotomy and this was carried out by B. P. Flannery on March 7 via a transverse right lower abdominal incision. The ascending colon, cæcum, and terminal ileum appeared to be normal on their peritoneal surfaces but were anchored to a retroperitoneal mass. The liver was normal. No other intra-abdominal lesion was noted apart from a few enlarged lymph-nodes near the origin of the iliocolic artery. The appendix was recognizable only in its proximal portion, the distal part terminating in a retroperitoneal mass which extended behind the cæcum and terminal ileum and involved quadratus lumborum and psoas muscles. The lesion had the gross appearance of an adenocarcinoma which had extensively invaded the retroperitoneal tissues and had spread to the regional lymph-nodes. Right hemicolectomy was performed, but only partial clearance of the retroperitoneal extension was possible. The wound was closed with drainage to the retroperitoneal space. Post-operatively he made a satisfactory recovery which was uneventful except for a persistent discharge from his wounds.

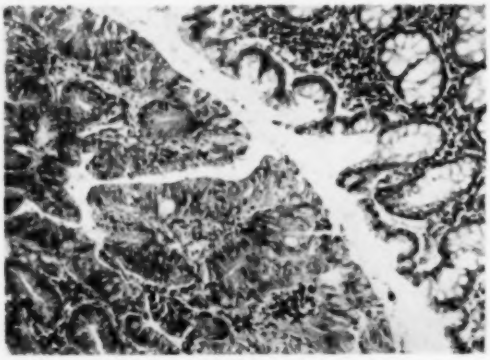


FIG. 629.—*Case* 1. High-power view showing a junction between normal tissue and tumour. There is fairly well-marked tubule formation. H. and E. (× 75.)

The pathologist reported on a section from the appendix stump and on tissue from the posterior abdominal wall. The former showed a moderately differentiated adenocarcinoma perforating the wall of the appendix and apparently arising from the appendix itself (*Figs.* 628, 629). The latter consisted of further portions of adenocarcinoma with some pyogenic granulation tissue.

The patient was seen at a joint consultative clinic of surgeons and radiotherapists at St. Helier Hospital on April 1, 1959. They concluded that it was doubtful whether radiotherapy was indicated at that stage. He was discharged from hospital on April 11. When he was last seen in the out-patients' clinic on April 28 his wounds were soundly healed and he was completely symptom-free.

Case 2.—Mrs. L., a 78-year-old married white female, was admitted to St. Anthony's Hospital on Jan. 1, 1959, complaining of abdominal pain and vomiting of 18 hours' duration.

Her symptoms had begun suddenly as generalized colicky abdominal pain with vomiting and two loose stools during the first four hours of the attack. On the morning of admission her pain shifted to the right iliac fossa where it persisted. There was no further vomiting and her bowels had not been open on the day of admission.

She had had one previous, milder, bout of abdominal pain and vomiting three weeks previously, for which she had remained in bed at home for a week. She also gave a history of diabetes mellitus of four years' standing, for which she was having 28 units of lente insulin daily. Apart from a mild stroke two weeks before admission, which resulted in weakness of her right arm and face, and slurring of her speech, she had had no significant illnesses in the past. The only relevant family history was the death of one brother from carcinoma of the lung.

FIG. 630.—*Case* 2. Longitudinal section through the margin of the ulcer. The submucous zone of lymphoid tissue is absent. H. and E. (× 10.)

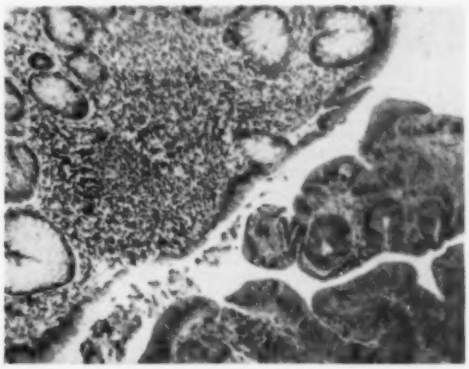


FIG. 631.—*Case* 2. Well-differentiated adenocarcinoma is seen adjacent to an acute inflammatory reaction in the 'normal' appendicular mucosa. H. and E. (× 86.)

On examination she was noted to be obese and somewhat flushed. Her temperature was 97·8°, pulse 84, and respirations 20 per minute. She was not dehydrated, her tongue was moist and clean, and there was no fœtor oris. She was mildly dyspnœic, but no gross abnormality of respiratory or cardiovascular systems was detected. Her blood-pressure was 120/70.

Examination of her abdomen revealed marked tenderness, well localized to the right iliac fossa, with moderate guarding and rebound tenderness. There was no palpable mass. The abdomen was not distended and bowel-sounds were normal. No abnormality was found on vaginal or rectal examination. The only other physical abnormality noted was moderate weakness of her right arm and face and slurring of her speech.

A diagnosis of acute appendicitis was made and operation was performed by G. H. Cook on the same day. Having in mind the possibility of a perforated carcinoma or diverticulum of the cæcum or ascending colon in one of her age, a right paramedian incision was made.

She was found to have a markedly thickened and acutely inflamed appendix which contained a hard mass in its middle third. This was thought to be most probably a large fæcolith, but on opening the appendix a malignant ulcer of ½ in. (1·25 cm.) diameter and encircling the lumen of the appendix was found. An examination of the regional lymph-nodes and liver revealed no evidence of spread of the growth. This fact, together with her advanced age, decided us to do no more than simple appendicectomy.

Her post-operative recovery was uneventful and she was discharged from hospital on the sixteenth post-operative day. She was well when she was last seen two months after operation.

The specimen was taken to the Royal College of Surgeons, where histological examination was made. The tumour was a well-differentiated adenocarcinoma infiltrating the whole thickness of the appendix wall and associated with an acute inflammatory reaction (*Figs.* 630, 631). The mucous membrane was abnormal. It was of the intestinal type and lacked the usual submucous zone of lymphoid tissue.

DISCUSSION

Incidence.—Primary adenocarcinoma of the vermiform appendix is a rare occurrence. If, however, the figure of 1 case in 2300 appendicectomies is a true indication of its incidence one must infer that the total number of cases occurring in the countries from which our information has been drawn must greatly exceed the number which has been reported.

While it is reasonable to suppose that many known cases have not been published, it is also possible that a significant number have escaped detection. This might well occur when the growth is at an early stage and where routine histological examination is not made. The fact that the operation of appendicectomy is commonly performed by the most junior surgeons may also be significant in this regard.

Adenocarcinoma of the appendix is said to occur more commonly in males than in females and is most common in the fifth, sixth, and seventh decades. In a review of 49 cases in which the sex was given, 31 were male and 18 were female (Niceberg and others, 1956).

Diagnosis.—Adenocarcinoma of the appendix has never been diagnosed pre-operatively. The majority of cases have presented as acute appendicitis (Muller and Taylor, 1958), some have been discovered at laparotomy for some other disease, while others have been diagnosed only after histological examination of an appendix which showed some firm enlargement and thickening (Brown and Husni, 1957). *Case* 1 is unusual in presenting as a recurring abscess which led to a discharging sinus in the loin. Niceberg and others (1956) found that in 50 cases only 6 presented as loin abscesses.

Treatment and Prognosis.—The treatment of choice for adenocarcinoma of the appendix is right hemicolectomy (Kiser, Case, Cawley, and Stofer, 1956). If necessary this should be done as a second operation when the diagnosis has been proved histologically, unless, as in *Case* 2, there is a reason for

choosing a more conservative procedure. Niceberg and others (1956) have shown that when simple appendicectomy was done (26 cases) 26·9 per cent were dead of the disease in three years, whereas where right hemicolectomy was performed (12 cases) only 8·3 per cent died subsequently from metastatic carcinoma. In the individual case the prognosis will obviously depend on the extent to which the growth has invaded the appendicular wall.

SUMMARY

Two new cases of adenocarcinoma of the appendix are reported. Neoplastic lesions of the appendix are classified and discussed briefly. The diagnostic difficulty of adenocarcinoma of the appendix is illustrated by an unusual clinical picture in which a recurring abscess in the right loin eventually discharged pus containing malignant cells. Radiological investigations over a period of two months failed to show any abnormality other than failure of the appendix to fill in either barium enema or barium trace.

A review of the literature indicates the rarity of this lesion.

Treatment and prognosis of adenocarcinoma of the appendix are discussed.

Acknowledgements.—Our thanks are due to Mr. H. A. Kidd for permission to publish his cases; to Dr. Proger and Dr. Goodier for their advice and for the slides to obtain *Figs.* 628–631; and to Mr. David Borrett for the photomicrographs.

REFERENCES

ASHLEY, D. J. B. (1958), *Brit. J. Surg.*, **45**, 372.

BROWN, H. W., and HUSNI, E. A. (1957), *Surgery*, **42**, 953.

BURTON, J. A. S. (1947), in *British Surgical Practice*, vol. 1. London: Butterworth.

KISER, W. J., CASE, L. G., CAWLEY, L. P., and STOFER, B. E. (1956), *J. int. Coll. Surg.*, **25**, 566.

MULLER, L. P., and TAYLOR, M. T. (1958), *J. Indiana med. Ass.*, **51**, 488.

NICEBERG, D. M., FELDMAN, S., and MANDELBERG, A. (1956), *Surgery*, **40**, 560.

UIHLEIN, A., and MCDONALD, J. R. (1943), *Surg. Gynec. Obstet.*, **76**, 711.

WILLIS, R. A. (1948), *Pathology of Tumours*, 426. London: Butterworth.

MULTIPLE CARCINOID TUMOURS OF THE ILEUM

REPORT OF A CASE

BY CHARLES G. CLARK AND R. N. CURNOW

DEPARTMENT OF SURGERY, UNIVERSITY OF ABERDEEN, AND ABERDEEN ROYAL INFIRMARY

CARCINOID tumour of the small intestine is comparatively rare, though multiple primary tumours exist in 20–50 per cent of cases (Le Brun, 1954). Dockerty and Ashburn (1943) cited a case where sixty-eight separate tumours were found. While Hudson (1956) considers that the majority of these tumours are benign, Sauer, Dearing, Flock, Waugh, Dockerty, and Roth (1958) state that they are malignant, and may metastasize.

The clinical features associated with malignant carcinoid and metastases are now well recognized. First appreciated by Biorck, Axen, and Thorson (1952), though earlier described by Cassidy (1931), these curious phenomena of flushing attacks accompanied by diarrhœa and dyspnœa appeared to result from some substance produced in the tumour. Lembeck (1953) found that carcinoid tumours contained large quantities of 5-hydroxytryptamine (5-HT), and Pernow and Waldenstrom (1954, 1957) were able to demonstrate increased circulatory 5-HT, or its urinary excretion metabolite 5-hydroxyindoleacetic acid (5-HIAA), in the majority of the cases studied.

While the classical 'carcinoid syndrome' is easily recognized, Smith, Nyhus, Dalgleish, Dutton, Lennox, and MacFarlane (1957) have stressed the fact that carcinoid with metastases is a protean disease and diagnosis may be extremely difficult. Since this is one type of metastasizing tumour where surgical treatment is often remarkably beneficial, early diagnosis is expedient. We have recently studied a case of atypical carcinoid syndrome which emphasizes the diagnostic difficulties, and our records of tumour tissue 5-HT assays and urinary 5-HIAA output are of interest.

CASE REPORT

W. W., a male aged 64 years, was admitted to hospital on March 24, 1956, with a complaint of persistent diarrhœa, noted eighteen months previously, and originally alternating with periods of constipation. Examination in another hospital at that time revealed a well-defined fixed abdominal mass situated to the right of the umbilicus. After inconclusive investigation, including X-ray studies, laparotomy was carried out in June, 1956, on a provisional diagnosis of carcinoma of the ascending colon. At operation, large neoplastic deposits were seen in the mesenteric lymph-nodes, but no primary tumour could be defined and the liver appeared to be free from metastases. A suitable biopsy was obtained, and the abdomen closed. Histology of this material showed features of lymphatic permeation but little cellular aberration or pleomorphism, and mitoses were inconspicuous. There was little doubt that the lesion was malignant and, though the possibility of carcinoid was considered, special staining was inconclusive.

Recovery from operation was uneventful, and a course of X-ray therapy was given. His condition remained unchanged as did the abdominal mass.

In January, 1957, he began to develop severe colicky abdominal pain, ascites, and ankle œdema. In March, 1957, he was admitted to Aberdeen Royal Infirmary at the request of his general practitioner, who considered the symptoms to be due to subacute intestinal obstruction.

ON ADMISSION.—The patient was an intelligent and observant man, who gave a lucid history. His main complaint was one of persistent watery diarrhœa, amounting to some three to five bowel movements a day, often accompanied by severe central abdominal pain, and

occasional vomiting. Increasing lethargy and progressive œdema were the other features noted in the three months before admission. He had never experienced any attacks of flushing or asthma, nor did fatty foods or alcohol give rise to any unusual sequelæ.

On Examination.—He was noted to have a malar flush, but he was adamant that this had been present as long as he could remember. There was no discoloration of the hands or feet. He was emaciated and there was both sacral and ankle œdema. The cardiovascular, respiratory, and central nervous systems were normal. The blood-pressure was 134/78 and there was no pyrexia. The abdomen showed a right paramedian scar and a large, fixed mass to the right of the umbilicus. The liver was not palpable, but ascites was demonstrated. On auscultation the bowel-sounds were very active. Rectal examination was normal, as was routine urine analysis.

A 24-hour specimen of urine was obtained and showed a total excretion of 60 mg. of 5-HIAA (normal 5-10 mg., Titus and Udenfriend, 1954). A diagnosis of malignant carcinoid tumour with metastases was made.

The following investigations were also carried out on admission:—

E.S.R., 14 mm. in first hour (Westergen).

Hæmoglobin, 58 per cent (Haldane). R.B.C., 2·85 million/c.mm.

W.B.C., 3900/c.mm. (neutrophils 87 per cent, eosinophils 3 per cent, lymphocytes 7 per cent). Platelets, 155,000/c.mm.

E.C.G., general myocardial ischæmia.

Proteins—total 4·64 g. per cent. Albumin 2·80 g. per cent. Globulin 1·84 g. per cent. A/G, 1·52/1.

Blood-urea, 47 mg. per cent.

Serum-bilirubin, less than 0·2 mg. per cent.

Serum alkaline phosphatase, 52 units.

Thymol turbidity, 3 units.

Stool benzidine series, negative.

C.S.U., deposit normal. Culture negative.

Barium meal (Dr. A. Stewart): At 2½ hours the barium lies in rather dilated loops of small bowel which appear to be closely approximated, suggesting some degree of adhesion between them. At 3½ hours a filling defect is noted in one of the loops and the terminal ileum shows an area of narrowing. The appearances are consistent with a tumour of the lower small bowel, or with Crohn's disease.

Course and Treatment.—Further laparotomy was considered advisable to relieve obstruction. Prior to operation a salt-free, high-protein diet was given in addition to neptal 2 c.c. intramuscularly. Blood transfusions raised

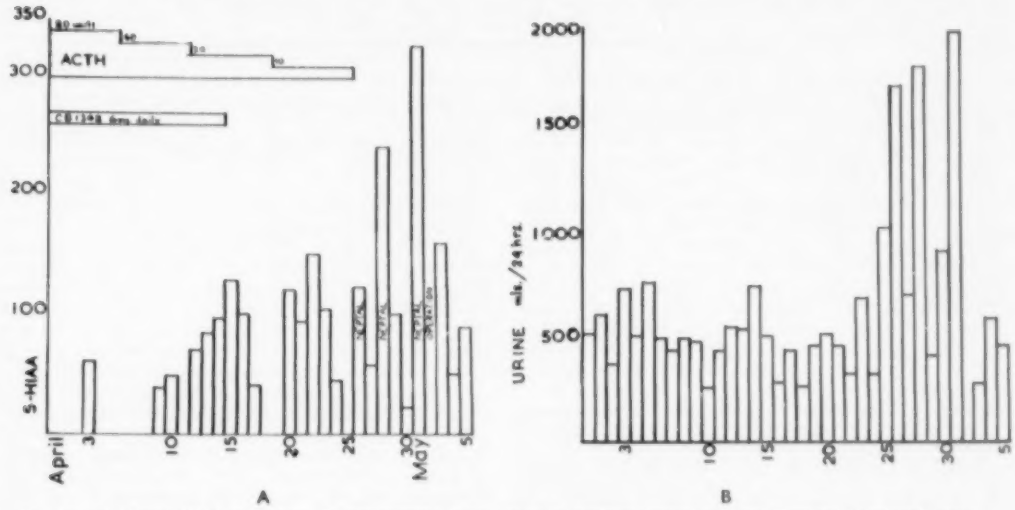


Fig. 632.—A, Urine 5-HIAA estimations. Results expressed in mg. per 24-hr. specimen (normal 5–10 mg., Titus and Udenfriend, 1954). B, The corresponding 24-hr. urinary volumes.

Fig. 633.—Carcinoid metastasis in the wall of the left atrium.

the hæmoglobin to 86 per cent but there was little general improvement and the œdema persisted. Serial urinary 5-HIAA estimations were carried out, but occasionally specimens were incomplete. A course of C.B. 1348 (chlorambucil) 6 mg. daily was given for fifteen days. ACTH was also given, as shown in *Fig.* 632. These had no effect on his general condition.

At Operation.—On May 2 a laparotomy was performed. The small bowel was somewhat distended and showed intense spasm on handling. Three separate tumours were palpated in the terminal ileum, and here the bowel was densely adherent to the retroperitoneal glands, the mesentery being obliterated. The patient's condition deteriorated during anæsthesia, and though it

was planned to remove some of the carcinoid tissue it seemed wise to be content with an ileotransverse anastomosis to relieve the obstruction. Following operation his condition remained poor and on the fifth post-operative day deteriorated rapidly. He died on May 8.

AT AUTOPSY.—Permission for post-mortem examination was limited to examination through the abdominal wound. A suppurative peritonitis was found, and seen to be due to perforation through the distal carcinoid tumour. This tumour showed central necrosis and was situated 20 cm. above the ileocæcal valve, lying near the apex of a gangrenous loop of ileum, the result apparently of neoplastic infiltration of the local mesentery with pressure on the supplying vessels. A second tumour was found 8 cm. proximal to this, and a third 16 cm. proximal. The tumours were 2, 1·5, and 1 cm. in diameter respectively. A large mass comprising lymph-nodes and infiltrated mesentery was noted. The liver appeared to be normal in size, but by inspection and palpation eight secondary deposits were identified. The heart was removed and found to contain a secondary deposit in the wall of the left atrium (*Fig.* 633). There was no pulmonary stenosis or right ventricular hypertrophy. Histologically the primary and secondary tumours showed features characteristic of argentaffinoma. Cellular aberration was noted, but metastases were inconspicuous. The tumour tissues removed at post-mortem were stored and later assayed for 5-HT content and the results are given in *Table I*.

Table I.—THE 5-HT CONTENT OF TUMOUR TISSUE FROM THE PRESENT CASE COMPARED WITH OTHER PUBLISHED RESULTS

TISSUE	5-HT, μg./g. WET WEIGHT	OTHER VALUES	AUTHORS
Ileum	0·4		
Carcinoid		>1 μg./g.	Stacey (1957)
Proximal	2	2·5 mg. g.	Benign tumour. Lembeck (1953)
Middle	2·7	0·9 mg. g.	Tumour tissue biopsy. Page and others (1955)
Distal	55·5	0·8 mg. g.	Case 4. Stacey (1957)
		0·32 μg./g.	Case 3. Snow and others (1955)
		61 μg./g.	Goble and others (1955)
Metastases		17·1 μg./g.	Liver. Thompson (unpublished)
Liver	6·2	0·08 μg./g.	Liver. Case 3. Snow and others (1955)
Liver	6·4	0·58 mg. g.	Liver. Case 2. Snow and others (1955)
		0·20 mg. g.	
		0·36 mg. g.	Liver. Goble and others (1955)
		0·3 mg. g.	Liver. Smith and others (1957)
Heart	22·7	72·5 μg. g.	Peritoneum. Thompson (unpublished)
		4 mg. g.	Humerus. Smith and others (1957)
		0·6 mg. g.	Case 2. Stacey (1957)
		0·7 mg. g.	Case 4. Stacey (1957)
		1·1 mg. g.	Case 5. Stacey (1957)

DISCUSSION

It would seem that the carcinoid syndrome has been adequately described in recent years for clinical diagnosis to be made with confidence in the typical case. Sandler and Snow (1958) have suggested that the clinical picture, in general terms, varies directly with the amount of tumour tissue present. Smith and others (1957), however, have stressed that the unique feature of the disease is its protean nature, and cite cases which presented initially as gastro-intestinal, cardiovascular, peripheral vascular, and renal disorders. MacFarlane (1957), in a survey of 5 cases, confirmed by urinary 5-HIAA estimations, extends this remark by showing that urinary 5-HIAA cannot be correlated with the clinical picture or the distribution of tumour tissue.

It is desirable to be aware of the mode of presentation of the atypical case, but the most important diagnostic point is an appreciation of the early symptoms of the disease, for the typical carcinoid syndrome is a case of advanced disease with widespread metastases. Clinical attention has tended to focus on the dramatic skin manifestations. The possibility that diarrhœa may be due to carcinoid is less often considered, and this case report helps to illustrate its importance.

Although there is some contradiction in terms, most authors are agreed that deranged intestinal motility is a notable feature of the disease. Duncan, Garven, and Gibbons (1955), in summarizing recorded cases, found diarrhœa present in all, and Stacey (1957) comments that most cases with general symptoms have at some time suffered from watery diarrhœa. Sinclair (1957) considers that continuous activity of the gut is the characteristic feature of intestinal function in this syndrome, and finds increased borborygmi present even when diarrhœa is absent, though he states that this feature is not pathognomonic. In a review of 200 cases he found diarrhœa as a symptom in 25 per cent and, with 4 exceptions, metastases were also present.

The initial symptom in the present case was watery diarrhœa, and this persisted even when partial intestinal obstruction supervened. The fact that intestinal hyperactivity has been noted even after removal of the primary intestinal tumour suggests that this symptom is due to the direct effect of 5-HT on the gut, and is not simply the result of mechanical effects of the carcinoid. Experimental work on the role of 5-HT in the intestine has given interesting results. In isolated tissue preparations, Kosterlitz and Robinson (1957) found that 5-HT applied externally to the intestine would inhibit peristalsis. Bulbring and Lin (1957) showed that small doses of 5-HT applied to the mucosa allowed the peristaltic reflex to be more easily elicited, increasing the frequency of peristalsis and the amount of fluid transported. They concluded that 5-HT may act by sensitizing the sensory receptors which trigger the peristaltic reflex, and that this substance is essential for normal peristalsis. The effect of 5-HT on the intestine in situ has been less fully studied, though Lembeck (1958) deduced that a very slight increase in serum 5-HT would be capable of increasing the propulsive activity of the

gut. We were impressed at operation by the remarkable way in which strong contractions of the small intestine could be induced even by the gentlest manipulation.

Experimental infusion of 5-HT in normal individuals is limited, by uncomfortable side-effects, to a dose of 1 mg./min. No episodes of flushing have been noted with this dosage (Page, Corcoran, Udenfriend, Sjoerdsma, and Weissbach, 1955), but the serum 5-HT assays of Pernow and Waldenstrom (1954) suggest that much higher concentrations of 5-HT are present in cases of carcinoid with flushing attacks. Dyspnœic attacks have not been observed experimentally, although hyperpnœa and exaggerated respiratory movements may occur. Abdominal pain and a desire to defæcate have been noted in some cases (Page, 1954).

These findings suggest that one of the first effects of excess 5-HT production in man would be on the intestine. We would therefore expect to find increased intestinal activity as an early symptom of carcinoid, and diarrhœa is simply a more severe expression of this activity. 5-HT is normally formed and stored in the mucosa of the intestine, and is released by various substances—fat (Bleehen, 1955); alcohol (Snow, Lennard-Jones, Curzon, and Stacey, 1955); reserpine (Green, Paasonen, and Giarman, 1957; Todrick, Dick, and Tait, 1958). To explain the absence of these features in some cases we draw attention to the case recently described by Sandler and Snow (1958) where diarrhœa had never been present. They found very small quantities of 5-HT in the tumour tissue but large quantities of 5-hydroxytryptophan (5-HTp), and a comparatively low urinary 5-HIAA. Both 5-HTp and 5-HT are derived from tryptophan, 5-HTp being the precursor of 5-HT, and pharmacologically inactive. It is, however, decarboxylated to 5-HT at extrarenal sites, and further decarboxylated to be excreted as 5-HIAA. They cite a case where diarrhœa was not a feature and further cases from Smith and others (1957) and Waldenstrom, Pernow, and Silver (1956) are alluded to. Diarrhœa would not be expected in these cases except as a result of mechanical effects of the tumour, or if peripheral 5-HTp decarboxylation were sufficient to give rise to increased serum 5-HT levels. Low values of urinary 5-HIAA in the cases cited suggest that this is unlikely.

The other features of this case are of doubtful significance. Although a malar flush was present, the patient had never experienced attacks of flushing, nor did abdominal palpation or a test dose of alcohol precipitate such an attack. The œdema, usually ascribed to heart failure, seems more likely to have been the result of hypoproteinæmia. We regret that no estimation of serum 5-HT was carried out.

Neither CB 1348 nor ACTH appeared to have any significant effect on the course of the disease. The metabolism of 5-HT and excretion of 5-HIAA are probably unchanged, although there is no suitable control period for comparison. CB 1348 was selected for trial because of the relative absence of gastro-intestinal side-effects. Although the duration of the treatment was brief, no benefit was noted. It is unlikely that a cytotoxic agent would have an effect on a tumour with few mitoses. In this respect it is interesting to note the dramatic but temporary improvement of symptoms by Goble, Hay, and Sandler (1955) using colloidal gold (Au^{198}). They suggested that an inhibitor of mono-amine oxidase might be inactivated by this means, allowing quicker metabolism of 5-HT. The expected increase in urinary 5-HIAA was not found, however. The pharmacological 5-HT antagonists, dibenziline, lysergic acid diethylamide (L.S.D.), and 'Bol 148', its brominated derivative, have not proved useful clinically, and were not given to the patient.

The estimations of urinary 5-HIAA are of interest. It is seen that on some occasions less than 20 mg./24 hr. and on one occasion only 11 mg./24 hr. was estimated. The examination of a single specimen of urine as a screening test may therefore miss the diagnosis. The greatest amount of 5-HIAA (338 mg./24 hr.) is excreted following the administration of neptal. 5-HIAA is filtered by the glomerulus and actively excreted by the tubules (Despopoulos and Weissbach, 1957). The kidney may be influenced by 5-HT, and Erspamer (1955) regards 5-HT as a hormone regulating intrarenal hæmodynamics, without affecting pituitary antidiuretic hormone. It has an antidiuretic effect possibly mediated by constriction of the afferent glomerular bed.

The occurrence of obstructive symptoms called for surgical intervention, and in view of the established diagnosis it was hoped to remove some of the tumour tissue, including the primaries. Despite metastases to the liver this appears to be a justifiable procedure in those cases with severe symptoms, for the reduction in secreting tissue is said to give symptomatic relief for a time, and Thorson, Biorck, Bjorkman, and Waldenstrom (1954) have demonstrated this in one of their cases. These tumours are characteristically of slow growth (Dockerty, 1955), many examples of long survival, even in the presence of metastases, being recorded (Cope, 1930; Thorson and others, 1954; Fraser, 1955). If our impression of the importance of 5-HT on the gut is correct, however, there would be little likelihood of alleviating gastro-intestinal symptoms unless all tumour tissue was eradicated or some degree of tolerance developed. Tolerance to 5-HT has been demonstrated in other tissues (Reid and Rand, 1952; Gaddum, 1953), and this fact has been used to explain the fluctuant nature of the skin manifestations.

The 5-HT assays of tumour tissue are noted. There is wide fluctuation in the results of other authors. Our values are very much less than those of Lembeck (1953), who assayed a benign tumour, or Page and others (1955), who assayed biopsy material, and in agreement with the result of Goble and others (1955), with regard to the primary tumour only. The assay of 5-HT in normal intestine from the patient compares favourably with the result of Stacey (1957). It may be that methods of extraction and assays are responsible for the wide variation. G. Curzon and J. W. Thomson (unpublished) found a marked difference in assaying acid and acetone extracts from the same tumour, using both biological and chromographic methods, nor was the discrepancy uniform. In the present case acetone extracts were assayed on a very sensitive and specific preparation (see APPENDIX). Other factors, such as the interval between death and removal of tissues (15 hr.), and the length

of storage of the tissues (6 mth.) in the frozen state, may have affected the results. We consider that the finding of normal values for 5-HT content of the ileum supports the view that the tissues did not deteriorate during storage. The low values for liver secondaries may be the result of the action of locally plentiful amine oxidase on 5-HT during the interval between death and necropsy. The figures for liver secondaries agree closely with the results obtained by Curzon and Thomson (unpublished) in another case.

One other feature which may be discussed without reference to deterioration, since the storage conditions were identical, is the remarkable difference in 5-HT content of the three individual tumours. The lower tumour contains 15 to 20 times the 5-HT per gramme of the others. It is interesting to speculate that this may be the only malignant tumour of the group, a fact sometimes difficult or impossible to establish histologically with certainty.

The occurrence of a cardiac metastasis (a rare finding in disseminated carcinoma) has not to our knowledge been recorded previously in this disease. This tissue had a 5-HT content roughly half the value of the most active primary, and again it is regretted that no blood estimations of 5-HT were made in this unusual case.

It is usually accepted that cardiac valvular lesions are of late occurrence, and in some way related to contact of the valves with blood of high 5-HT content. The mechanism of skin lesions is also in doubt, and whether it is due to the direct effect of 5-HT to sudden fluctuations in 5-HT released by certain stimuli, or to release of histamine, is as yet undetermined. They have almost invariably occurred in the presence of multiple liver secondaries, as, indeed, have the cardiac lesions. In our case not only were the liver secondaries few in number and small, but the tumour 5-HT content is also low. This may explain the absence of more widely appreciated features of the disease and serve to emphasize the prominent and early symptom, diarrhœa, which experimental and clinical evidence suggests is an early and important diagnostic feature.

SUMMARY

A case of carcinoid with metastases is described. The major symptom was diarrhœa, and the significance of this is discussed. Reasons are given which suggest that gastro-intestinal upset may be an early symptom of the disease, and that the effect is a physiological and not a mechanical response.

Serial urinary 5-HIAA estimations and the results of tumour-tissue assays are given. Results suggest that only one of three possible primary tumours had metastasized, the others being relatively or definitely benign.

APPENDIX

The method of Macfarlane, Dalgleish, Dutton, Lennox, Nyhus, and Smith (1956) was used to determine urinary 5-HIAA.

5-HT was extracted from tumour tissues with acetone after the manner of Erspamer (1956), and assayed for activity on the rat fundal strip, as described by Vane (1957). This method is sensitive to concentrations of 1×10^{-11} 5-HT, and comparatively insensitive to histamine except in high dosage. Responses to choline derivatives are annulled by using a hyoscinated perfusate. The specificity of each assay was tested with the antagonist L.S.D. (lysergic acid diethylamide), which was effective in a dose of 1×10^{-6}.

Acknowledgements.—We are grateful to Professor W. C. Wilson and to Mr. Andrew Fowler for permission to publish this report.

Professor Russell Fraser has kindly allowed us to publish results from one of his cases, and we thank Dr. G. Curzon and Dr. J. W. Thompson for allowing us to publish the details.

The X-ray studies were carried out by Dr. A. M. Stewart and the histology by Dr. H. G. Richmond.

Dr. J. R. Vane kindly demonstrated the method of 5-HT assay and we are especially grateful for his criticism and advice.

REFERENCES

Biorck, G., Axen, O., and Thorson, A. (1952), *Amer. Heart J.*, **44**, 143.
Bleehen, N. A. (1955), *Lancet*, **2**, 1362.
Bulbring, E., and Lin, R. C. Y. (1957), *J. Physiol.*, **138**, 12P.
Cassidy, M. A. (1931), *Proc. R. Soc. Med.*, **13**, 866.
Clark, C. T., Weissbach, H., and Udenfriend, S. (1954), *J. Biol. Chem.*, **210**, 139.
Cope, Z. (1930), *Brit. J. Urol.*, **2**, 268.
Curzon, G., and Thomson, J. W., personal communication.
Despopoulos, A., and Weissbach, H. (1957), *Amer. J. Physiol.*, **187**, 548.
Dockerty, M. B. (1955), *Amer. J. clin. Path.*, **25**, 794 (Editorial).
— — and Ashburn, F. S. (1943), *Arch. Surg., Chicago*, **47**, 221.
Duncan, D., Garven, J. D., and Gibbons, J. L. (1955), *Brit. med. J.*, **2**, 1586.
Erspamer, V. (1955), *J. Physiol.*, **127**, 118.
— — (1956), *Ibid.*, **133**, 1.
Fraser, I. (1955), *Lancet*, **2**, 144.
Gaddum, J. H. (1953), *J. Physiol.*, **121**, 15P.
Goble, A. J., Hay, D. R., and Sandler, M. (1955), *Lancet*, **2**, 1016.
Green, J. P., Paasonen, M. K., and Giarman, N. J. (1957), *Proc. Soc. exp. Biol., N.Y.*, **94**, 428.
Hudson, R. E. B. (1956), *Proc. R. Soc. Med.*, **50**, 37.
Kosterlitz, H. W., and Robinson, J. A. (1957), *J. Physiol.*, **136**, 249.
Le Brun, H. (1954), *Brit. J. Surg.*, **42**, 20.
Lembeck, F. (1953), *Nature, Lond.*, **172**, 910.
— — (1958), *5-Hydroxytryptamine*, 147. London: Pergamon Press.
MacFarlane, R. S. (1957), *Proc. R. Soc. Med.*, **50**, 443.
— — Dalgleish, C. E., Dutton, R. W., Lennox, B., Nyhus, L., and Smith, A. N. (1956), *Scot. med. J.*, **1**, 148.
Page, I. H. (1954), *Physiol. Rev.*, **34**, 563.
— — Corcoran, A. C., Udenfriend, S., Sjoerdsma, A., and Weissbach, H. (1955), *Lancet*, **1**, 198.
Pernow, B., and Waldenstrom, J. (1954), *Ibid.*, **2**, 951.
— — — — (1957), *Amer. J. Med.*, **23**, 16.
Reid, G., and Rand, M. (1952), *Nature, Lond.*, **169**, 801.
Sandler, M., and Snow, P. J. D. (1958), *Lancet*, **1**, 137.
Sauer, W. G., Dearing, W. H., Flock, E. V., Waugh, J. M., Dockerty, M. B., and Roth, G. M. (1958), *Gastroenterology*, **34**, 216.

SINCLAIR, I. S. R. (1957), *Proc. R. Soc. Med.*, **50**, 447.
SJOERDSMA, A., WEISSBACH, H., and UDENFRIEND, S. (1956), *Amer. J. Med.*, **20**, 520.
SMITH, A. N., NYHUS, L. M., DALGLEISH, C. E., DUTTON, R. W., LENNOX, B., and MACFARLANE, R. S. (1957), *Scot. med. J.*, **2**, 24.
SNOW, P. J. D., LENNARD-JONES, J. E., CURZON, G., and STACEY, R. S. (1955), *Lancet*, **2**, 1004.
STACEY, R. S. (1957), *Proc. R. Soc. Med.*, **50**, 40.
THORSON, A., BIORCK, G., BJORKMAN, G., and WALDENSTROM, J. (1954), *Amer. Heart J.*, **47**, 795.
TITUS, E. O., and UDENFRIEND, S. (1954), *Fed. Proc.*, **13**, 411.
TODRICK, A., DICK, M., and TAIT, A. C. (1958), *Brit. med. J.*, **1**, 496.
VANE, J. R. (1957), *Brit. J. Pharmacol.*, **12**, 344.
WALDENSTROM, J., PERNOW, B., and SILVER, H. (1956), *Acta med. scand.*, **156**, 173.

ANTECUBITAL STRINGS—A NEW PHYSICAL SIGN?

BY H. H. G. EASTCOTT, LONDON
CONSULTANT SURGEON, ST. MARY'S HOSPITAL, W.2

AMONG the several discomforts which may follow radical mastectomy is one so slight in comparison with the others that it must often be overlooked, and in fact it does not seem to have been described before. The patient experiences a tight feeling at the elbow flexure on the operated side: extension of the joint is often limited by it. Movements of the upper limb soon after this operation are generally painful, but if this actual complaint of anterior elbow stiffness or tightness is specifically made by the patient, and the region of the flexure is examined closely the reason will often be seen. One or more stringy bands are found to cross the flexure (*Fig.* 634), their general direction being from the inner side of the upper arm to the anterior and lateral surface of the forearm. If the skin in the line of these bands be drawn gently apart so as to place them slightly on the stretch, they will be seen much more clearly. Active extension of the elbow may likewise bring them into prominence. It is evident that they are not the familiar veins of the antecubital fossa for they do not disappear with pressure upon them, nor on elevation of the limb; moreover they are in a very superficial plane of the subcutaneous tissue, even being slightly attached to the skin itself. An inch or more above and below the line of the flexure the bands appear to pass into a deeper plane, but by maintaining tension upon them their further course can usually be felt; they pass upwards and inwards and gain the line of the brachial vessels as far as the axilla, but can be felt within the superficial fascia most of the way.

FIG. 634.—Front of left elbow showing typical antecubital strings following radical mastectomy (*Case* 5).

FIG. 635.—Front of right elbow in *Case* 14 who had undergone block removal of the axillary lymph-glands for lymphosarcoma three months before. Note separate identity of large antecubital veins.

Identification of the Bands.—In January, 1951, the first case of this complication was noted (*Table I*,

Case 1), and at the time the possibility was considered that this might be evidence of a malignant process

FIG. 636.—Front of left elbow in *Case* 12, a man aged 21 years with mild axillary adenitis.

lay in a much deeper plane. Portions were taken for histological section, and no carcinoma could be found. This patient has remained well: it is now over nine years since her operation. Though it was realized that the antecubital bands were not necessarily of serious significance, from then on all patients undergoing radical mastectomy were scrutinized for this physical sign, in the hope of explaining it.

Incidence.—In the 18 cases observed, 8 had undergone radical mastectomy for carcinoma. A similar dissection, but of the axilla only, was the preceding factor in one patient; in this instance the diagnosis was lymphosarcoma (*Fig.* 635). Six patients had no axillary operation before their strings were found (*Fig.* 636): in 4 of these lymphatic glandular enlargement was noted in the corresponding axilla. One of this group was shown to have carcinoma deposits from a primary on the back of the hand (*Fig.* 637). Two patients had limited axillary operations before the strings were noticed (*Fig.* 638).

The ages of the patients ranged from 12 to 75 years; 9 were women, of whom 8 had carcinoma of the breast. Only 2 of the men had malignant disease as the associated condition.

In 3 cases bands appeared in places other than the elbow. *Fig.* 639 shows some very similar strings in the posterior cervical triangle and the lateral thoracic wall in a woman who had undergone radical mastectomy on this side a year before (*Case* 4). The antecubital fossa was also affected (*Fig.* 640), and in this instance one of the strings bore a rounded fusiform swelling. The patient declined exploration of this. Six months later she returned, complaining

Table I.—PATIENTS DEVELOPING ANTECUBITAL STRINGS AFTER RADICAL MASTECTOMY

CASE NO.	AGE	DATE OF OPERATION	STRINGS NOTED	RADIOTHERAPY	HEALING	REMARKS
1	50	Dec. 12, 1950	3 wk.	Pre-operative	First intention	Alive and well. No nodes involved
2	29	March 22, 1951	4 wk.	Pre- and post-operative	Delayed	Some skin necrosis. Clinical and histological invasion of lymph-nodes. Last seen Nov. 3, 1953 with multiple bony deposits
3	67	July 31, 1953	3 mth.	Pre-operative	Some delay	No recurrence by 1956. Nodes histologically involved
4	44	April 27, 1953	11 mth.	Post-operative	First intention	Strings on arm, neck, and chest, preceded a local glandular recurrence (*see* text). Died 2 yr. 11 mth. after operation
5	50	Aug. 1, 1953	9 mth.	None	First intention	Alive and well. Nodes not involved. Late appearance of strings, but no recurrent Ca
6	57	March 24, 1954	4 wk.	Pre-operative	Large skin-graft. Some delay	Pain before strings for 3 wk. Alive and well. Nodes not involved
7	48	July 11, 1958	2 wk.	Pre-operative	First intention	Axillary gland involved
8	44	Jan. 27, 1959	1 mth.	Pre-operative	First intention	Axillary glands affected. Upper end of strings fixed to axillary scar

either in some remaining axillary lymphatic tissue, or in the superficial brachial lymph-trunks themselves. The lesion was therefore explored, and it was found to be composed of string-like bands lying just beneath the skin, away from the main antecubital veins which

of further lumps, and was found to have enlarged lymph-nodes in the left axilla and in the left posterior triangle.

One patient, with a primary tuberculous lesion in the hand and an enlarged axillary gland, showed

A B

FIG. 637.—Site of former primary carcinoma in *Case* 13 showing (A) line of secondary deposits and (B) antecubital strings apparently in continuity with this line of tissue. Axillary deposits were present.

Table II.—PATIENTS DEVELOPING ANTECUBITAL STRINGS OTHER THAN AFTER RADICAL MASTECTOMY

CASE NO.	AGE	SEX	UNDERLYING CONDITION	TIME OF APPEARANCE OF STRINGS	REMARKS
9	39	M.	Subacute axillary abscess for 5 wk. Surgical drainage. Sterile pus. Leucocytosis 13,000/c.mm.	11 d. after operation	*See Fig.* 638
10	21	M.	Palmar and brachial abscesses drained 1 wk. following the appearance of a red band along the limb	11 d. after operation	*See Fig.* 642
11	52	M.	Seborrhœic dermatitis. Excision of chronically enlarged axillary nodes	14 d. after operation	
12	21	M.	Mild axillary adenitis	Uncertain	
13	75	M.	Squamous-cell Ca. of dorsum of hand, enlarged axillary node, deposits along the line of the string	5 mth. after removal of the primary lesion	*See Fig.* 637. Axillary node and string lesions contained growth. Since developed pleural effusion on the same side
14	60	M.	Lymphosarcomatous glands removed from axilla	"Almost at once"	Died within a year. *Fig.* 635
15	12	M.	Abrasion of knuckle	About a week	String was on the dorsum of the hand (*Fig.* 641)
16	43	F.	Tuberculous ulcer of wrist	? 3 mth.	Axillary node palpable
17	41	M.	Mild axillary adenitis	Some weeks	
18	44	F.	Unknown 'Pain in veins in straightening elbows'	Uncertain. 2 mth ?	Both arms affected

strings in the wrist and forearm proximal to the affected region, and another, a boy of 12 years, with a tiny abrasion of the third knuckle, was seen with a curious beaded vessel-like structure on the dorsum of this hand (*Fig.* 641) which disappeared within a week. No enlarged lymph-nodes were noted in this case.

There was frank suppuration in *Case* 10 (*Fig.* 642). He developed two small abscesses along the line of

the brachial string, which in this case was restricting elbow extension very noticeably. His initial lesion was a palmar abscess.

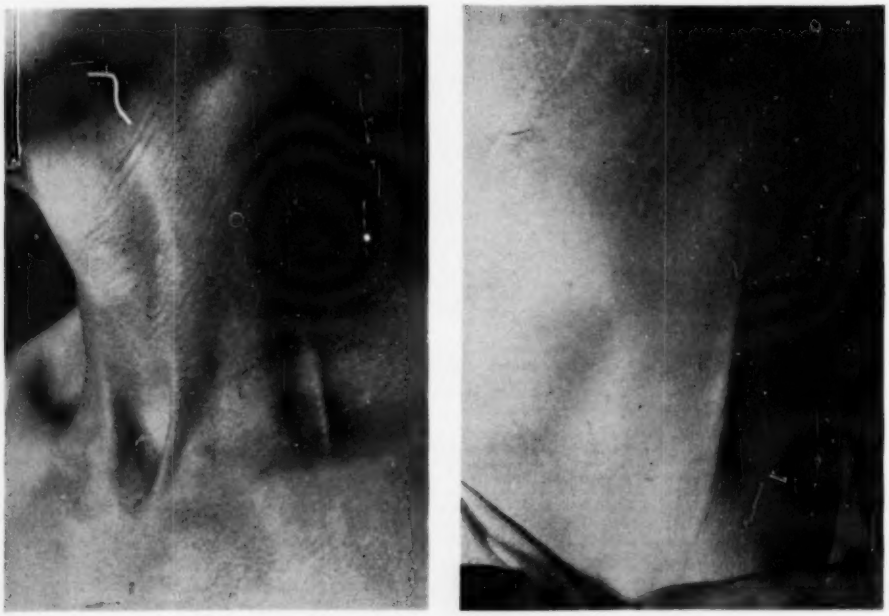
FIG. 638.—Front of right elbow in *Case* 9 in which an axillary abscess had been drained five weeks before.

ANATOMICAL CONSIDERATIONS

In this situation most of the structures lie in a regular and familiar order, and the possible anatomical sites for these rather constant abnormal bands are limited. Lymphatic trunks in this region do pass across the flexure in a superficial plane, and are unrelated to the antecubital veins: they incline a little medially as they run up the limb, towards the axillary lymph-glands, but remain superficial all the way. The next deeper layer of vessels is composed of the joining and rebranching figure of the large antecubital veins, H-, M-, or N-like, and in no way corresponding to the abnormal bands which we are considering. Mostly beneath these are the main, named cutaneous nerves. From these features and from the constant association with some lymphatic glandular abnormality in the case-histories it was considered that the superficial lymph-trunks might well be the site of the tight antecubital strings, and several cases were studied from this point of view.

Patent Blue V Studies.—As a control experiment in each case, 0·2–0·5 ml. of 11 per cent Patent Blue V dye was injected intracutaneously into the middle of the flexure surface of the forearm on the unaffected side. A normal response consists in the appearance within 10–15 minutes of one or more blue streaks traversing the elbow flexure (*Fig.* 643 A). No such streaks were observed after such an injection on the affected side (*Fig.* 643 B) in 5 cases, but not all showed a normal response on the other side.

Direct Study of the Trunks.—Once it was realized that the condition is self-limiting, further operations to investigate it were not thought to be



A B

FIG. 639.—Strings in (A) left posterior cervical triangle and (B) pectoral region in *Case* 4.

justifiable, but before this stage *Cases* 1 and 3 (*Fig.* 644) had already been operated upon with the primary object of excluding a malignant infiltration as the local cause, and in both cases an attempt at angiography was made, but without success, for, finding it to be a pale, whitish string just beneath the skin, not resembling a lymphatic and not like a normal vein in its appearance either. He injected 4·5 ml. of 70 per cent Diodone after a little difficulty in finding the lumen, and obtained the angiogram shown in *Fig.* 646. This shows the structure to be a vein, ending in the axillary, and possibly related proximally to the enlarged axillary gland.

FIG. 640.—Front of left elbow in *Case* 4. Axillary and cervical glandular deposits appeared six months later.

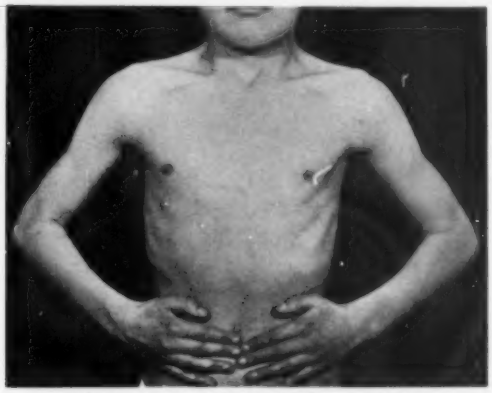
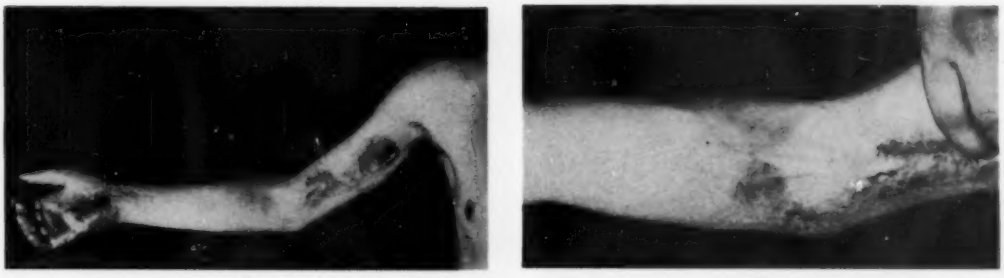


FIG. 641.—Back of right hand in *Case* 15, showing abrasion of third knuckle.



A B

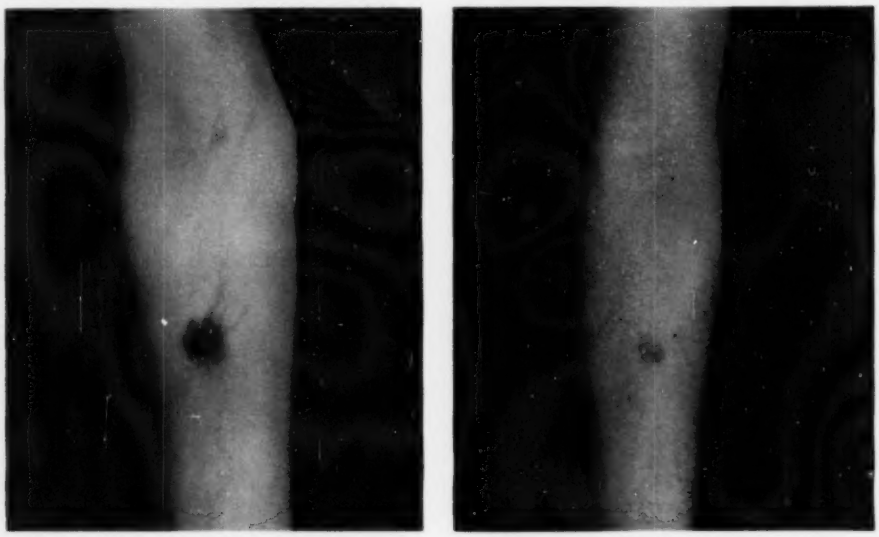
FIG. 642.—A, Drained brachial abscesses in *Case* 10, along line of string. B, Taut antecubital string, limiting elbow extension.

DISCUSSION

Most of the indirect evidence in this investigation pointed to a lymphatic origin for the strings. It is true that there was never any association with lymphœdema, in which similar findings were obtained by Devenish and Jessop (1940) using Patent Blue V as the subsequent microscopical examination of the specimens showed, the vessels were thrombosed. Quite recently, however, *Case* 17 afforded a new opportunity. The subject in this case was the author, who had noticed an antecubital string on his own left arm while palpating an enlarged and tender axillary gland (*Fig.* 645) probably secondary to a split in the skin of the nail fold of the left index finger. Professor J. B. Kinmonth kindly agreed to explore the lesion and after a negative result from a Patent Blue V injection into the corresponding skin area of the upper radial part of the forearm, he did so, injections, but it was felt that this might be because only the superficial lymph-trunks were involved, and deep lymphatic drainage should be normal.

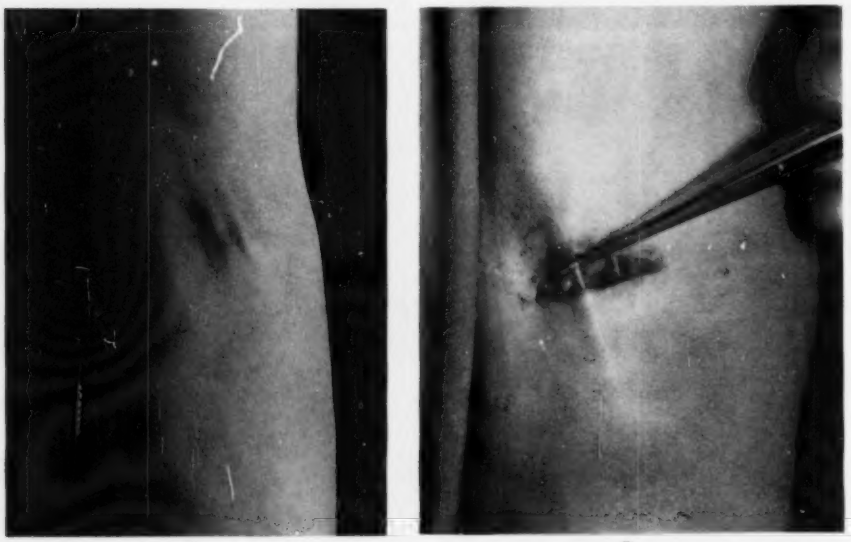
Histological examination of the biopsy material from *Cases* 1 and 3 was inconclusive. One showed thrombosed vessels in fat, the vessels being probably veins, and in the other the thrombosed vessels were not identifiable with certainty. In *Case* 17 the vessel was reported upon by Dr. John Pinniger as a small vein in supporting connective tissue. There was slight intimal fibrosis, but no inflammatory cells could be identified. This case, since the lumen was patent,

presented the first opportunity for successful angiography and proved that in this instance the string was a small, rather tightened superficial vein draining freely, however, into the axillary. Reviewing the series were very similar to those of the explored group. It may well be that the lesion is always in a vein. But these are not the large antecubital veins of everyday experience, formed, as the anatomical



A B

FIG. 643.—A, Normal streaming of Patent Blue V dye injection along lymph-trunks in unaffected arm in *Case* 5. B, Negative Patent Blue V test in affected limb of *Case* 5.



A B

FIG. 644.—A, Front of left elbow in *Case* 3. B, Appearance of strings at operation in this patient. Vessels could not be injected and were histologically thrombosed.

previous operative findings and material in the light of this case it did seem likely that in the other two explored cases the strings were also of venous origin. Clinically, most of the strings through the whole pictures show, from the many small tributaries of the forearm, wrist, and hand. No small superficial veins appear in the antecubital region in the anatomy textbooks, but they must be there, for the proximal part

of the skin sleeve must have its small venous channels as much as the distal, and these unfamiliar vessels do in fact pass up in the superficial fascia to join the axillary radicles high up, and at this point they are often in close relation to the superficial axillary lymph glands.

There is a condition, Mondor's disease of the breast and pectoral region, which, as Professor Kinmonth pointed out, resembles quite closely the one we are considering. Reviewing the literature on this, the similarity was striking. Mondor himself (1939) considered the possibility of a lymphatic origin for the strings which he had found beneath the pectoral skin; he used traction along them to show them up, but he finally concluded that a stringy phlebitis was the cause. Earlier, Robinson (1935) had described a similar string appearance of the pectoral region in a case of traumatic subclavian venous thrombosis. Adair (1950) mentioned the sign in connexion with breast carcinoma, but emphasized that it was not necessarily of grave significance. He also pointed out that in one case, on exploration he found a 2-cm. axillary gland in relation to the proximal end of the stringy vein near its junction with the axillary. Lunn and Potter (1954), describing 5 personal cases, reviewed the literature on Mondor's disease and traced the evidence over the years as to its possible lymphatic or venous origin. They conclude from their own and the other available evidence that the small vessels concerned are probably always venous, and that it is self-limiting, though one may have to look for, and treat, the underlying cause. All this is very much what one pictures in the arm condition, and the author agrees with Kinmonth that we are dealing with Mondor's disease of the arm. There appears to be only one case of this in the literature (Stevenson, 1954). It is of interest to note that in *Case* 4 of the present series strings were present in the arm, neck, and pectoral regions, and that the latter lesion (*Fig.* 639) would fit the classical description of Mondor's disease.

FIG. 645.—Front of left elbow in *Case* 17, showing effect of traction in axilla.

FIG. 646.—Angiogram in *Case* 17 shows the vessel to be a vein.

SUMMARY

1. After radical mastectomy, and in some conditions affecting the axillary lymph-glands, one or more string-like bands may appear close beneath the elbow flexure.

2. This condition has been studied in 18 cases and it appears to be due to a tightening, and in some cases a thrombosis, of the fine subcutaneous veins draining to the axilla.

3. It closely resembles Mondor's disease of the breast.

Acknowledgements.—I am indebted to Professor J. B. Kinmonth for his valuable help and advice; to Professor C. G. Rob for permission to publish my observations on several of his cases, likewise to Professor C. A. Pannett for *Case* 14, and to Dr. G. B. Mitchell-Heggs for *Case* 16, and also to Dr. P. N. Cardew, in whose Department at St. Mary's Hospital the photographs were prepared.

REFERENCES

ADAIR, F. E. (1950), *Practitioner*, **165**, 473.
DEVENISH, E. A., and JESSOP, W. H. G. (1940), *Brit. J. Surg.*, **28**, 222.
LUNN, G. M., and POTTER, J. M. (1954), *Brit. med. J.*, **1**, 1074.
MONDOR, H. (1939), *Mem. Acad. Chir. Paris*, **65**, 1271.
ROBINSON, R. H. O. B. (1935), *Brit. J. Surg.*, **23**, 296.
STEVENSON, F. H. (1954), *Brit. med. J.*, **1**, 1207.

URETERIC REFLUX IN THE PARAPLEGIC

By J. COSBIE ROSS, MAREK DAMANSKI, AND NORMAN GIBBON
FROM THE LIVERPOOL REGIONAL PARAPLEGIC CENTRE, SOUTHPORT

INTRODUCTION

URETERIC reflux of clinical importance is a late complication of paraplegia, being discovered in less than 5 per cent of cases within three years of the injury (Hutch and Bunts, 1951), and in as many as 17 per cent at the end of seven years (Lord and Bunts, 1956). As only selected cases are subjected to cystography, the true incidence of the complication is probably higher than this. The condition has become of increasing importance largely owing to the successful results achieved in the treatment of traumatic paraplegia during the last few years and the consequent longer survival of these patients.

We must refer at the outset to the suggestion made by some authorities (Graves and Davidoff, 1923; Eisendrath, Katz, and Glasser, 1925) that a distinction should be drawn between *reflux* (that is, passive backwash through a diseased and dilated orifice) and *regurgitation* (that is, backflow through a normal orifice, such as has been demonstrated in the experimental animal when the bladder actively resists filling). No such distinction will be made here as the two terms are usually used indiscriminately and as it is probable that in the paraplegic bladder no ureteric orifice remains strictly normal for very long.

During recent post-mortem experiments on the isolated human bladder and prostate (Gibbon, 1957), one of us was impressed by the fact that leakage never occurred from the ureteric stumps even when there was evidence of chronic retention of urine. This observation, which was recorded many years ago by Young (1897), suggests the existence of a flap-valve at the ureterovesical junction so efficient as to be largely, if not wholly, independent of muscular and nervous activity. As Sampson (1903) pointed out, the ureteric orifice is a fixed point and with increased distension of the bladder the intramural ureter becomes increasingly oblique. He emphasized that the lumen of the intramural ureter is round when the bladder is empty and flattened when the bladder is distended. He considered reflux to be prevented under normal conditions by the compression exerted between the bladder wall on the one hand and the increasing intravesical pressure on the other.

The development of ureteric reflux may often be indicated clinically by a sudden onset of pyrexia due to pyelonephritis or bacteriæmia. This has sometimes been noted in association with a blocked catheter, after closure of a suprapubic cystostomy and following various endoscopic procedures. It is sometimes possible to identify by palpation which side is affected, though in high paraplegia this may be difficult. Precise investigation of the phenomenon, however, requires radiological examination. Unfortunately, interpretation of the cystographic results is difficult, because reflux is influenced by the pressure and volume of fluid in the bladder (Bors and Comarr, 1952) and may be demonstrated for the first time after an interval of several hours (Stewart, 1955). In addition, as the same author has suggested, reflux through a grossly diseased orifice may be prevented by kinking of a tortuous lower ureter.

All reports agree that ureteric regurgitation is extremely rare in the normal subject at all ages. The higher incidence found among children with enuresis (Forsythe and Whelan, 1958) may be an indication of the effect of increased bladder tone and uninhibited bladder contractions on the normal ureteric orifice. As shown by Bumpus (1924), infection appears to be a more important causative factor than obstruction (*Table I*). The almost invariable development of reflux after re-implantation of the ureter into the bladder without the formation of a valve seems to be of particular significance (Henderson, 1953).

Table I.—INCIDENCE OF URETERIC REFLUX (Bumpus, 1924)

	per cent
Prostatic hypertrophy	4·7
Infection:—	
Tuberculosis	39
Pyelonephritis	19
Post-prostatectomy	11
After partial cystectomy	33

The cause of reflux is still a matter of conjecture and we do not propose to enter into a detailed discussion of this subject here, especially as the physiology of the ureter is still disputed. It may be presumed that the ureterovesical valve is rendered ineffective by local structural changes. Hanley (1959) has noted on cine-cystography that reflux is quite common in simple cystitis in otherwise healthy subjects and the importance of pan-ureteritis in the development of reflux and ascending infection in the paraplegic has been stressed by Talbot (1958). Hutch (1958) believes that there is often a thinning and weakness of the bladder wall in the vicinity of the intramural part of the ureter, with the result that a hernia-like saccule develops in the bladder wall immediately above the ureteric orifice, the course of the intramural ureter becoming shortened and less oblique.

It must be admitted that ureteric reflux may appear suddenly without any discoverable cause and disappear in an equally inexplicable manner. This fact must be constantly kept in mind and precipitate treatment avoided as it may be unnecessary. Bunts (1957), for example, has reported disappearance of reflux in 80 per cent of cases following simple drainage.

The present survey is a retrospective one involving only those cases of traumatic paraplegia which have required cystography for the investigation of persistent retention of urine. Some of the difficulties of interpretation referred to above are offset in our series by the fact that all the cystographic studies have been carried out personally by one of us (M. D.) according to a standardized technique described elsewhere (Damanski and Kerr, 1957). On the other hand, our observations on reflux are quite incidental to the main purpose of restoring bladder function. The picture to be presented may, therefore, appear

fragmentary as well as indistinct, but we believe that certain interesting features are recognizable.

INCIDENCE OF REFLUX

Of 248 cases of paraplegia admitted to date, 136 have required cystography. In 52 only a single cystographic examination was made, but in some instances the procedure was repeated as often as seven or eight times. Among the 155 traumatic cases which form the basis of this survey, 101 were submitted to a total of 292 cystographies. Reflux was found in 39 of these patients on one or more occasions. The condition was bilateral in 22 and unilateral in 17, the incidence in the latter group being approximately equal on the two sides (*Table II*). In our series reflux was commonly observed at an early stage (*Table III*), without gross disease of the bladder wall, and it is in such cases that the condition has disappeared spontaneously or after the establishment of efficient bladder emptying.

FIG. 647.—Retrograde cystogram showing Grade 1 reflux on the right side and Grade 2 on the left.

Table II.—INCIDENCE OF URETERIC REFLUX AT THE LIVERPOOL REGIONAL PARAPLEGIC CENTRE

Number of patients with traumatic paraplegia			155
Subjected to cystography			101
Patients with reflux	Unilateral	17	39
	Bilateral	22	

Table III.—TIME OF FIRST OBSERVATION OF REFLUX

	Under 6 mth.	*6–12 mth.*	*1–2 yr.*	*2–3 yr.*	*Over 3 yr.*
Cases	15	7	3	6	7

CLASSIFICATION

For the purposes of comparison, we have divided reflux into three grades, as suggested by Damanski and Kerr (1957):—

1. Filling of the lower ureter only (*Fig.* 647).
2. Filling of the whole ureter and kidney pelvis without much dilatation (*Fig.* 647).

FIG. 648.—Retrograde cystogram showing bilateral reflux, Grade 3.

3. Filling of a dilated upper urinary tract (*Fig.* 648).

We regard this classification as of importance, especially with regard to treatment. It will be seen from *Table IV* that the intermediate grade of reflux has been found more often than either of the others.

Table IV.—CLASSIFICATION OF REFLUX

Grade	*Right*	*Left*
1	9	9
2	13	13
3	10	7
Total	32	29

ASSOCIATED FEATURES

1. Level of the Cord Lesion.—As we have pointed out in a previous communication (Damanski and Gibbon, 1956), reflux is more frequently encountered in high than in low spinal injuries. This fact has also been commented on by others, notably Bors and Comarr (1952). It might be thought that the abdominal straining necessary to empty the lower motor neurone bladder would protect the

FIG. 649.—Retrograde cystogram showing generalized trabeculation and right reflux.

FIG. 650.—Retrograde cystogram showing a saccule near the lower end of each ureter and left reflux.

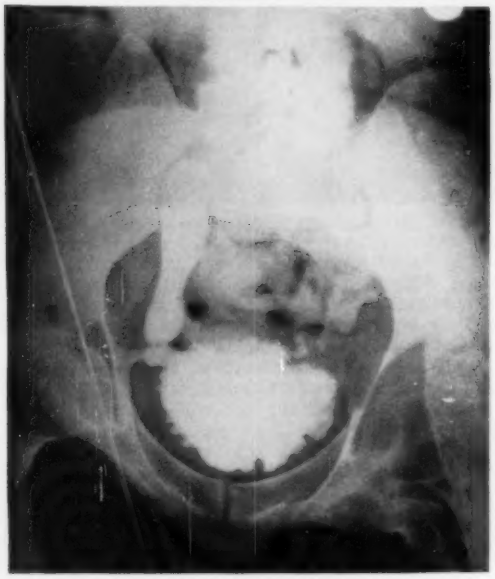


FIG. 651.—Retrograde cystogram showing how the lower end of the ureter runs below the saccule.

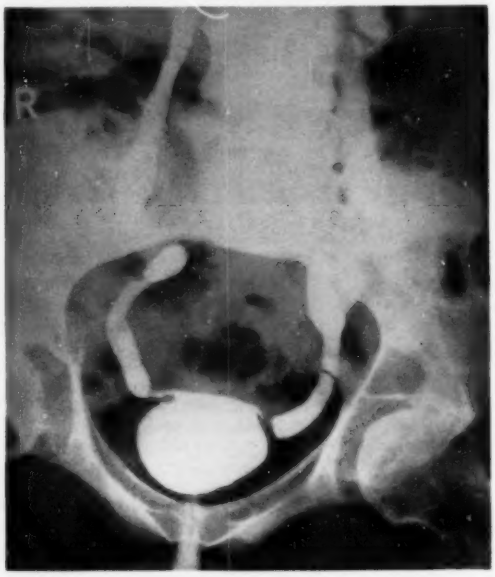
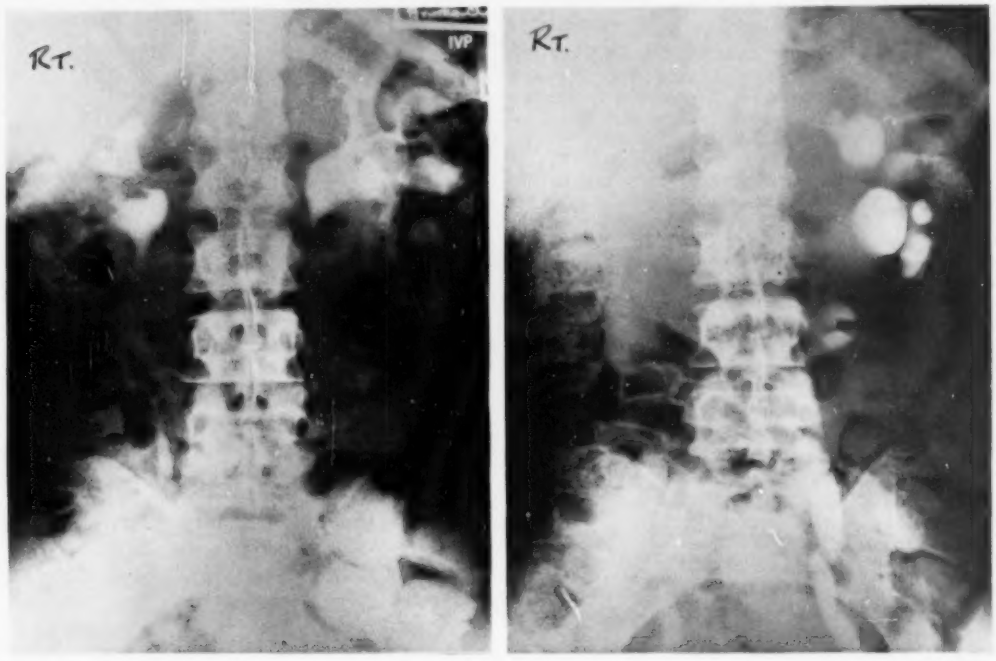


FIG. 652.—Retrograde cystogram showing a narrow segment at the lower end of each ureter.

upper urinary tract by exerting pressure on the ureters and counteracting the tendency to reflux. In our experience, however, there is no evidence that the type of bladder function is important in determining the existence of reflux, though it may well influence its effect. It may be, as Bors (1957) has suggested, that the preservation of the sympathetic innervation of the trigone in low lesions of the cord has some protective effect upon the ureteric orifices.

2. Infection.—As pointed out above, our patients form a selected group with persistent retention of urine. Only 4 of them did not require operation and the remaining 35 patients had 88 corrective operations carried out in order to establish voiding or to

eliminate a high residual urine. Catheterization has, therefore, been unusually prolonged and all the patients have had a chronic urinary infection aggravated by frequent unsuccessful trials of bladder emptying. It seems probable that inflammatory changes in the lower part of the ureter may have played an important part in the development of (*Fig.* 650). As shown in *Fig.* 651, the ureter runs below the saccule to open on its floor. The pouch lies within Waldeyer's sheath and may compress the lower end of the ureter. Hutch considers that the saccule, the so-called 'dog ear', indicates a thinning and weakness of the muscular wall of the bladder with the result that with filling and increased



A B

FIG. 653.—A, Excretion pyelograms in a case of traumatic paraplegia. B, Reflux left pyelogram in the same case a few days later.

reflux in many of these cases. Intractable infection, together with repeated chills and fevers, is an indication for active treatment of ureteric reflux.

3. Hypertonia and Trabeculation of the Bladder.—These two features appear to be of great importance and certainly the most constant findings in persistent reflux. There has been the usual high incidence of hypertonia in our series (*Table V*) and in only 14 out of 39 cases was the bladder wall smooth

Table V.—CYSTOMETRIC FINDINGS AT THE TIME OF REFLUX

Hypertonia	23
Hypertonic Reflex	2
Normotonia	5
Normotonic Reflex	6
Not known	3

Table VI.—CONDITION OF THE BLADDER AT THE TIME OF REFLUX

Generalized trabeculation	19
Localized saccule	6
Smooth-walled	14

at the onset of reflux (*Table VI*). In 19 there was generalized basal trabeculation (*Fig.* 649), whilst in 6 others a localized saccule was demonstrated radiologically in the region of one or both ureteric orifices intravesical pressure there is no structure against which the ureter may be compressed. The result of this is ureteric reflux. Hutch (1955) has shown typical changes of this type in the bladders of stillborn infants with urethral atresia, which indicates that obstruction is probably more important than infection in the aetiology of the saccule itself.

In 5 patients we have noted a narrow segment at the lower end of one or both dilated ureters and in 3 of these there was associated vesical trabeculation or saccule formation (*Fig.* 652). Hutch (1955) and Bunts (1957) have suggested that this narrow zone represents the intramural part of the ureter, displaced so as to lie outside the bladder wall. In this position it may obstruct the flow of urine by its lack of peristalsis (it has no circular muscle-fibres), or by kinking, and so promote hydronephrosis with or without regurgitation. We have not encountered any difficulty in passing a ureteric catheter in these cases and this is in accordance with Hutch's views.

4. Condition of the Ureteric Orifice.—For various reasons the cystoscopic appearance of the orifice at the time of reflux is known in only 32 instances. In 13 the opening was reported as normal,

while in 11 it was affected or obscured by inflammatory œdema (*Table VII*). Five ureteric orifices

Table VII.—CONDITION OF THE URETERIC ORIFICE AT TIME OF REFLUX

Normal	13
Œdematous, or obscured by cystitis	11
Patulous	5
In a saccule	3
Total	32

were patulous and 3 were observed to be lying in a saccule such as has been described above. Bors and Comarr (1952) have reported a similar proportion of apparently normal ureteric orifices in early reflux. It is clear, therefore, that the appearance of the orifice gives no indication as to the presence or absence of reflux, the diagnosis depending mainly on the radiographic findings.

EFFECTS OF URETERIC REFLUX

It is not easy to assess the effects of reflux on the kidney because hydronephrosis and uræmia can both occur with and without regurgitation. However, the dilatation of the upper urinary tract produced during reflux is sometimes striking (*Fig.* 653), and, clinically, the association with acute pyelonephritis is well known.

1. Hydronephrosis.—In 10 of our patients with reflux there was bilateral, and in 7 unilateral, hydronephrosis. As shown in *Table VIII*, the

Table VIII.—HYDRONEPHROSIS AND REFLUX

Bilateral hydronephrosis	Bilateral reflux	4	10
	Unilateral reflux	6	
Unilateral hydronephrosis	Ipsilateral reflux	4	7
	Bilateral reflux	3	

relationship between the two conditions suggests a causal basis. Further, the degree of hydronephrosis frequently corresponds to the grade of reflux observed. On one occasion regurgitation was associated with loss of function of the kidney without any evidence of pelvi-calyceal dilatation.

2. Uræmia.—Bunts (1958) reports that reflux has been responsible for many uræmic deaths, but this has not been our experience (*Table IX*). Apart

Table IX.—CHRONIC URÆMIA AND REFLUX

Total number of patients with traumatic paraplegia	155
Total number of deaths from chronic uræmia	18
With bilateral hydronephrosis	12
Unilateral reflux	1
Bilateral reflux	1
With unilateral hydronephrosis	3
(Contralateral) reflux	1
(Reflux not excluded in 7 cases)	

from these late effects, however, reflux may be responsible for a deterioration of renal function at a stage when the intravenous pyelogram is still normal. The same author has demonstrated a significant reduction of inulin and P.A.H. clearances in the presence of reflux in such cases.

One of us (J. C. R.) has recently operated on a patient with a neurogenic bladder due to a birth palsy. Starting with a normal intravenous pyelogram two years previously, progressive renal deterioration due to gross reflux eventually necessitated the implantation of the ureters into an ileal bladder.

We have noted, on several occasions, that closure of a long-standing suprapubic cystostomy has been followed by the development of reflux and upper urinary tract dilatation. Bors (1957) has also issued a warning against the hasty adoption of such a measure.

3. Infection.—We have pointed out in a previous communication (Ross, Gibbon, and Damanski, 1957) the great difficulty of maintaining sterility of the urine in the presence of dilatation of the ureter and

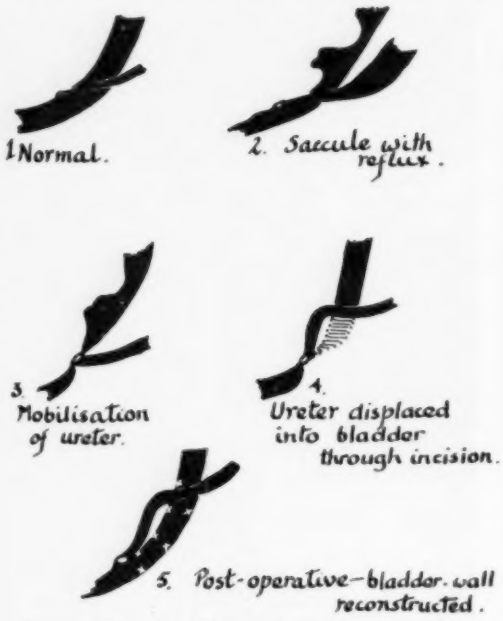

1 Normal.
2. Saccule with reflux.
3. Mobilisation of ureter.
4. Ureter displaced into bladder through incision.
5. Post-operative—bladder wall reconstructed.

FIG. 654.—Diagrams to illustrate the steps of an operation for the correction of ureteric reflux (*after Hutch*).

renal pelvis. There is no doubt that reflux renders the patient prone to chronic or recurrent urinary infection.

EFFECT OF IMPROVED BLADDER EMPTYING ON REFLUX

It has always been our view that obstruction at the bladder neck or at the external sphincter level

Table X.—EFFECT UPON REFLUX OF IMPROVED BLADDER EFFICIENCY

TREATMENT	CURED	IMPROVED	UNCHANGED	WORSE
None	1			
Catheter drainage		2		
Suprapubic drainage				1
Alcohol block	1			1
Pudendal neurectomy	2		2	1
Bladder-neck resection			3	
Division of external sphincter	1	1		
Combined resection	2			
Total	7	3	5	3

constitutes a major factor in the production of ureteric reflux. In the course of carrying out various procedures (bladder-neck resection, pudendal neurectomy, and division of the external sphincter) for the

relief of retention of urine in the paraplegic, we have observed the effect on ureteric reflux (*Table X*). In 18 patients with reflux a high residual urine was eliminated by subarachnoid alcohol block or by one or more of the surgical procedures mentioned above. there is a second factor dependent on some defect of the ureteric orifice. The importance of obstruction at or below the bladder neck is emphasized by those patients who, in the attempt to void, force urine into the dilated ureters.

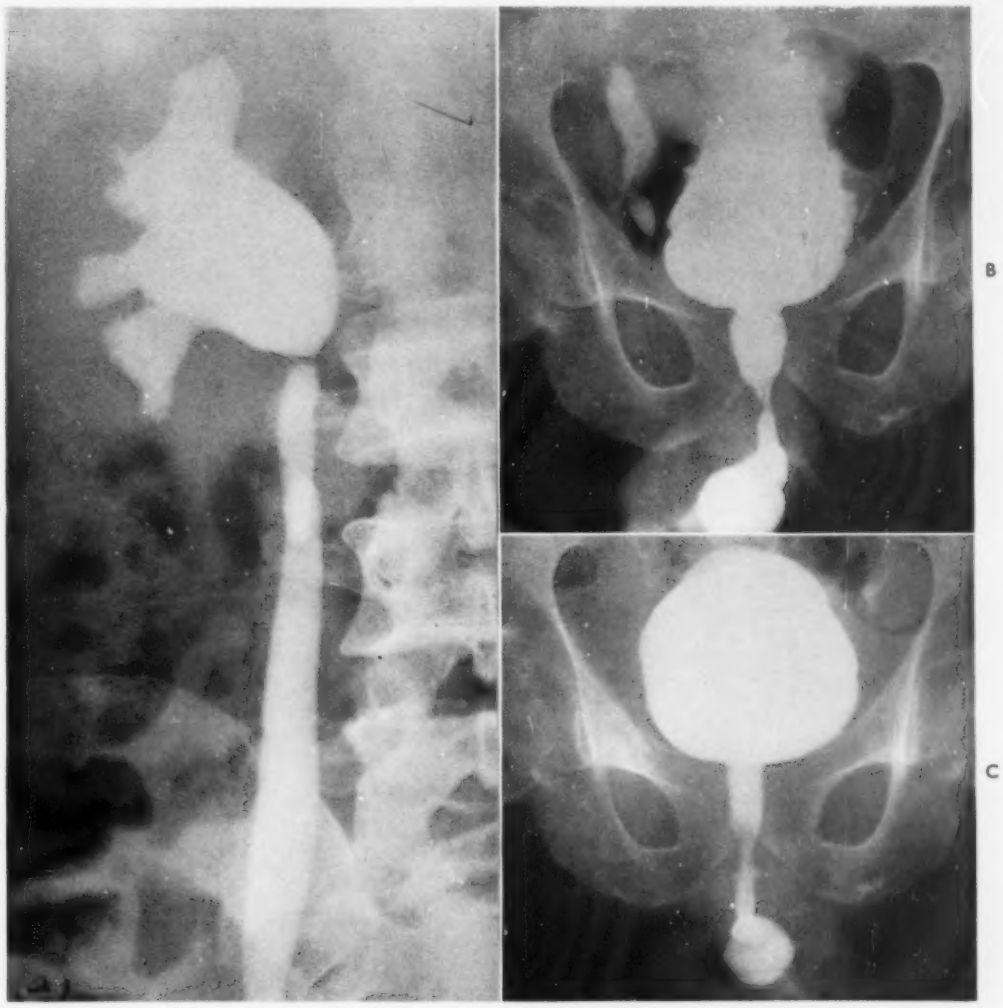


FIG. 655.—A, B, Right reflux (Grade 3) in a case with trabeculation of the bladder and a narrow segment at the lower end of the ureter. C, Retrograde cystogram following Hutch's operation showing absence of reflux on the right side.

Reflux disappeared or diminished in 10 of these cases, but in 8 there was deterioration or no change. It is significant that, in almost every case showing improvement of reflux, the bladder wall was free from trabeculation at the time. In all those showing an unfavourable response gross disease of the bladder wall or ureteric orifice was present. This observation confirms that although obstruction at the bladder neck, etc., may be a major factor in causing reflux,

We have attempted to assess the effect upon reflux of those subarachnoid alcohol blocks which were unsuccessful in relieving retention of urine. In 6 cases no obvious benefits accrued, suggesting that the effect of such an injection is exerted through a reduction in residual urine and infection. Contrary to some reports, we have not found hypertonia of the bladder to be affected favourably by subarachnoid alcohol injection. For example, 6 patients (including

4 with hypertonic bladders) had an alcohol block for severe flexor spasms. Cystometrograms performed within a few days of the injection showed that while in 2 cases the basic pressure curve was unaffected, in the remaining 4 it was actually higher than before. After some weeks or months, however, there may be found a reduction of hypertonia due, presumably, to abolition of reflex contractions and the gradual stretching of the bladder.

DISCUSSION

Increasing dilatation and infection of the kidneys necessitate further measures to prevent loss of renal function and uræmia; the correction of reflux plays an important part in management. We attempt to avoid permanent urethral or suprapubic drainage and regard these measures as a last resort. Nephrostomy is generally considered unsatisfactory, but we have carried out 'spout' ureterostomy and have implanted the ureters into an ileal bladder in a few cases of progressive reflux and hydronephrosis.

In the present series more than half of the patients exhibiting reflux were cured by eliminating obstruction at the bladder neck or at the external sphincter level. At the same time it must be freely admitted that attainment of efficient bladder emptying does not eliminate reflux if there is gross abnormality of the ureteric orifices, and it is in this type of case that the plastic operation advocated by Hutch (1952) should be given a trial. *Fig.* 654 illustrates the technique of the operation, which has been used not only for the correction of regurgitation but also to eliminate the functional obstruction produced when the intramural part of the ureter is displaced so as to lie outside the bladder. Successful results from this operation have now been reported from many centres (Vinson, Hutch, and Bunts, 1957) and we have, therefore, reviewed our problem cases from this point of view. We have, in fact, performed the Hutch operation on two occasions only (*Fig.* 655) but, in retrospect, we think that others of our patients might have been benefited by this procedure. On the other hand, it may be that in future fewer patients with irreversible reflux will be seen. Using, at an earlier stage, the various surgical procedures now at our disposal for the relief of retention, we hope to prevent the onset of serious pathological changes in the bladder wall. It is our impression that the incidence of clinically significant reflux has already fallen as a result of this policy and that early control of infection is also of major importance.

It is necessary to emphasize once more that ureteric reflux should be treated conservatively for a considerable time, mainly because the condition may well remain unchanged indefinitely or disappear spontaneously. Certainly it is not necessary to operate in the Grade 1 cases, i.e., those with dilatation of the lower third of the ureter. It is the progressive nature of the reflux, the hydronephrosis, and renal deterioration which necessitate drastic measures.

SUMMARY

1. Of 101 cases of traumatic paraplegia subjected to cysto-urethrography because of persistent retention of urine, ureteric reflux was found in 39 cases.

2. The only constant factors in persistent reflux were hypertonia, trabeculation, and infection.

3. The reflux was reversible by establishing efficient bladder emptying, provided that there were no gross anatomical changes at the ureteric orifices. It is considered that early elimination of bladder-neck obstruction probably provides the best chance of preventing the development of reflux.

4. Among those patients with permanent reflux were several with progressive deterioration of renal function who might have benefited by restoration of the valvular action of the lower end of the ureter. It would appear reasonable to give a trial to the Hutch operation before proceeding to more drastic measures such as the formation of an ileal bladder.

REFERENCES

Bors, E. (1957), *Urol. Surv.*, **7**, 177.
— — and Comarr, A. E. (1952), *J. Urol.*, **68**, 691.
Bumpus, H. C. (1924), *Ibid.*, **12**, 341.
Bunts, R. C. (1957), *Trans. Amer. Ass. gen.-urin. Surg.*, **49**, 199.
— — (1958), personal communication.
Damanski, M., and Gibbon, N. (1956), *Brit. J. Urol.*, **28**, 24.
— — and Kerr, A. S. (1957), *Brit. J. Surg.*, **44**, 398.
Eisendrath, D. N., Katz, H., and Glasser, J. M. (1925), *J. Amer. med. Ass.*, **85**, 1121.
Forsythe, W. I., and Whelan, R. F. (1958), *Brit. J. Urol.*, **30**, 189.
Gibbon, N. (1957), *Ibid.*, **29**, 258.
Graves, R. C., and Davidoff, L. M. (1923), *Trans. Amer. Ass. gen.-urin. Surg.*, **16**, 25.
Hanley, H. G. (1959), personal communication.
Henderson, D. St. C. L. (1953), *Brit. J. Urol.*, **25**, 3.
Hutch, J. A. (1952), *J. Urol.*, **68**, 457.
— — (1955), *Ibid.*, **74**, 795.
— — (1958), *The Uretero-vesical Junction*, 60. Berkeley and Los Angeles: University of California Press.
— — and Bunts, R. C. (1951), *J. Urol.*, **66**, 218.
Lord, K. H., and Bunts, R. C. (1956), *Ibid.*, **75**, 66.
Ross, J. C., Gibbon, N. O. K., and Damanski, M. (1957), *Lancet*, **2**, 520.
Sampson, J. A. (1903), *Bull. Johns Hopk. Hosp.*, **14**, 334.
Stewart, C. M. (1955), *J. Urol.*, **74**, 749.
Talbot, H. S. (1958), *J. Amer. med. Ass.*, **168**, 1595.
Vinson, C. E., Hutch, J. A., and Bunts, R. C. (1957), *J. Urol.*, **78**, 611.
Young, H. H. (1897), *Maryland med. J.*, **38**, 45.

THE MANAGEMENT OF ACUTE INTESTINAL OBSTRUCTION

A CRITICAL REVIEW OF 179 PERSONAL CASES

By PAUL T. SAVAGE

FROM THE WHITTINGTON HOSPITAL, LONDON, N.19

Of the four common surgical emergencies, acute appendicitis, perforated peptic ulcer, strangulated hernia, and intestinal obstruction, intestinal obstruction is wrongly diagnosed by far the most often, both in and outside hospital. Eleven years ago, in a monograph on this subject (Rodney Smith, 1948), it was suggested that while the mortality for acute appendicitis had fallen to well below double figures, the mortality for acute intestinal obstruction, in spite of the advances made during the late 'thirties and early 'forties, was still at least 15 per cent. Why is the diagnosis difficult, and has the mortality improved over the last eleven years? The records of 179 personal cases have been reviewed in an attempt to answer these and other questions.

Table I.—Acute Small-bowel Obstruction

	No. of Cases	*No. of Deaths*	*Mortality per cent*
Total number of cases	122	17	13
Cases under the age of 70 years	88	6	7
Cases over the age of 70 years	34	11	32

Table II.—Acute Small-bowel Obstruction

	No. of Cases	*No. of Deaths*	*Mortality per cent*
Cases with viable small bowel	94	11	12
Cases with gangrenous small-bowel	28	6	21
Cases with gangrenous small bowel under age of 70 years	18	1	6
Cases with gangrenous small bowel over age of 70 years	10	5	50

The first 38 cases were treated at the London Hospital and the West Middlesex Hospital, and I gratefully acknowledge the permission of those surgeons under whose care they were admitted for allowing me to treat them and include them in this series. The other cases were all treated at the Whittington Hospital, and include all the cases of acute intestinal obstruction admitted under my care since August, 1952. Cases of strangulated external hernia have been excluded, as it is considered that this condition presents a very different clinical and surgical problem, with a very much better prognosis. Three fatal cases of superior mesenteric arterial occlusion have also been excluded. One had embolic occlusion of the aorta at the level of the diaphragm, and died from thrombotic occlusion of the aorta at the same site following embolectomy. Another had embolic occlusion of the superior and inferior mesenteric and both common iliac arteries. Infarction of the gut formed only a part of these patients' trouble. A third survived, by 10 days, resection of the gut from within 18 in. of the duodenojejunal flexure to the ileocæcal valve.

Table III.—Causes of Acute Small-bowel Obstruction in 122 Cases

	No. of Cases
Bands and adhesions	59
Intraperitoneal abscess	7
Meckel's diverticulum	4
Internal hernia	8
Intussusception	18
Volvulus	9
Regional ileitis	2
Secondary carcinoma	5
Gall-stones	2
Post-operative	8

REVIEW OF CASES

Of the 179 cases, 27 died, an overall mortality of 15 per cent, which is increased to 16 per cent if the cases of embolic mesenteric vascular occlusion are included. Well over a third of these cases were over the age of 70 years. Of the 109 cases under the age of 70, only 7 died—a mortality of 6·5 per cent.

Of these 179 cases, 122 had small-bowel obstruction; there were 17 deaths, a mortality of 13 per cent. Many of the patients were old (34 over the age of 70 years, *see Fig.* 656). That age has a profound effect on the ability to survive acute small-bowel obstruction is shown in *Table I.* The mortality in 88 cases under 70 years of age was only 7 per cent. Over the age of 70, the mortality was 32 per cent. It is usually considered that the prognosis of small-bowel obstruction is adversely affected if there is gangrene of the bowel. In 94 cases with viable small bowel the mortality was 12 per cent, as compared with a 21 per cent mortality amongst 28 cases with gangrene of the bowel (*see Table II*). That this increased mortality occurred in the older age-groups is again shown in *Table II.* In patients with gangrene of the small bowel under the age of 70 years, the mortality was only 6 per cent, while in those over 70 it was 50 per cent. The various causes of small-bowel obstruction in this series are set out in *Table III.* They call for no special comment.

Table IV.—Large-bowel Obstruction

	No of Cases
Total	57
Cases due to carcinoma	43
Cases due to other causes	14
Deaths	10
Mortality per cent	18
Mortality in those under 80 years of age per cent	9

There were 57 cases of large-bowel obstruction, 43 of which were due to carcinoma. There were 10 deaths, an overall mortality of 18 per cent (*see Table IV*). The age distribution of these cases is shown in *Fig.* 657. Of these cases 34—almost two-thirds of the total—were over the age of 70 years; 10 were over the age of 80! Large-bowel obstruction is very much a disease of the elderly, and a mortality of almost 1 in 5 is therefore not surprising. The mortality amongst the 47 patients under the age of 80 was only 9 per cent. These figures include all deaths while in hospital, or within 6 weeks of operation, and therefore include the deaths occurring

during the second and third stages of those patients submitted to a three-stage procedure. Of the cases of large-bowel obstruction 43 were due to carcinoma, with a mortality of 12 per cent. The site of the

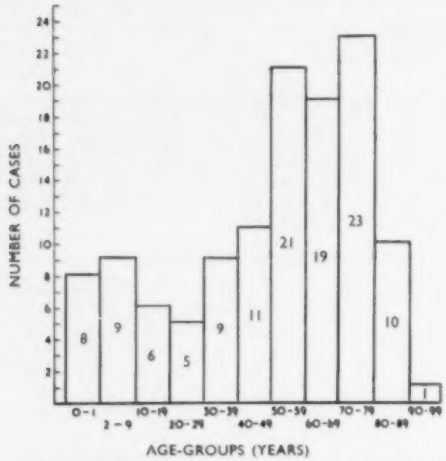


FIG. 656.—Age distribution of 122 cases of acute small-bowel obstruction. (Thirty-four cases are over the age of 70 years.)

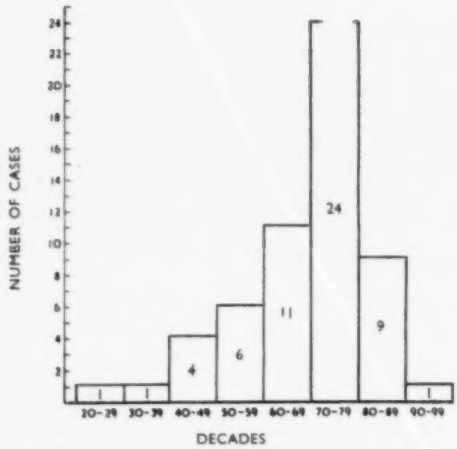


FIG. 657.—Age distribution of 57 cases of acute large-bowel obstruction. (Ten cases are over the age of 80 years.)

carcinoma causing obstruction is shown in *Table V*. Just over three-quarters of the lesions were on the left side of the large bowel. There were 14 cases due to causes other than carcinoma (*see Table VI*), with 5 deaths—a mortality of 36 per cent. Of these 5 deaths, 4 of the patients were over the age of 80 years, and the youngest 78.

Table V.—SITE OF PRIMARY IN 43 CASES OF LARGE-BOWEL OBSTRUCTION DUE TO CARCINOMA

	No. of Cases
Ascending colon	4
Hepatic flexure	1
Transverse colon	9
Splenic flexure	3
Descending and pelvic colon	11
Rectosigmoid	9
Rectum	6
Deaths	5
Mortality per cent	12

Diagnosis.—The diagnosis of acute intestinal obstruction is often easy, but by no means always so. In small-bowel strangulation obstruction there may be little to show soon after the onset of the illness, apart from severe continuous abdominal pain and a rather silent abdomen. Similarly the insidious onset of abdominal distension, without much pain, may be the only evidence of large-bowel obstruction in a decrepit senile patient, who is a poor witness, and habitually constipated anyway.

Little is likely to be learnt by tabulating the frequency with which the various classical features of intestinal obstruction occur. Pain, for example, may be continuous, colicky, extremely severe—or almost absent. Abdominal distension is tremendous in most cases of volvulus of the pelvic colon, but the patient with high small-bowel strangulation obstruction is usually moribund by the time it appears. Similarly with bowel-sounds. They may be increased in frequency or intensity at the onset of a simple small-bowel obstruction, become high pitched and tinkling in character a little later when the bowel becomes distended, or even absent in strangulation obstruction with infarction of a long length of bowel—a state of affairs which also exists in paralytic ileus. It is not surprising, therefore, that the diagnosis is sometimes overlooked.

Table VI.—LARGE-BOWEL OBSTRUCTION CAUSES OTHER THAN CARCINOMA

	No. of Cases
Ileocæcal volvulus	1
Volvulus of pelvic colon	7
Volvulus of splenic flexure	1
Bands and adhesions	4
Colocolic intussusception	1
TOTAL	14
Deaths	5
Mortality per cent	36

(Four out of 5 of the patients dying were over 80 and the youngest 78 years of age.)

The key to the problem of diagnosis lies in the intelligent appraisal of a careful history, a proper physical examination of the patient as a whole, and the abdomen in particular, in conjunction with the examination of supine and erect radiographs of the abdomen. The most important thing about the abdominal examination is that it should be unhurried. Fifteen minutes at the bedside is well spent if, at the end of it, the bowel goes into spasm with the production of a typical step-ladder pattern and a loud gurgle. It goes without saying that rectal examination, examination of the hernial orifices and of the vomit (or gastric aspirate) should never be omitted. On at least two occasions the fæculent nature of the vomit has been the only feature of the illness which made me suspect an obstruction, and the failure to recognize the presence of a non-tender insignificant strangulated femoral hernia has led to two unnecessary laparotomies. As with other conditions, you only diagnose what you look for, and the

possibility of obstruction should always be considered in any obscure illness in which abdominal pain, vomiting, or constipation feature.

Supine and erect radiographs of the abdomen, taken in conjunction with the other clinical features of the illness, are of tremendous help, not only in the diagnosis of the presence or absence of obstruction, but also in localizing its site (Assman, 1913; Davis, 1927; Case, 1928; Ochsner and Granger, 1930; Rabwin and Carter, 1930). *Fig.* 658 shows

Supine

Erect

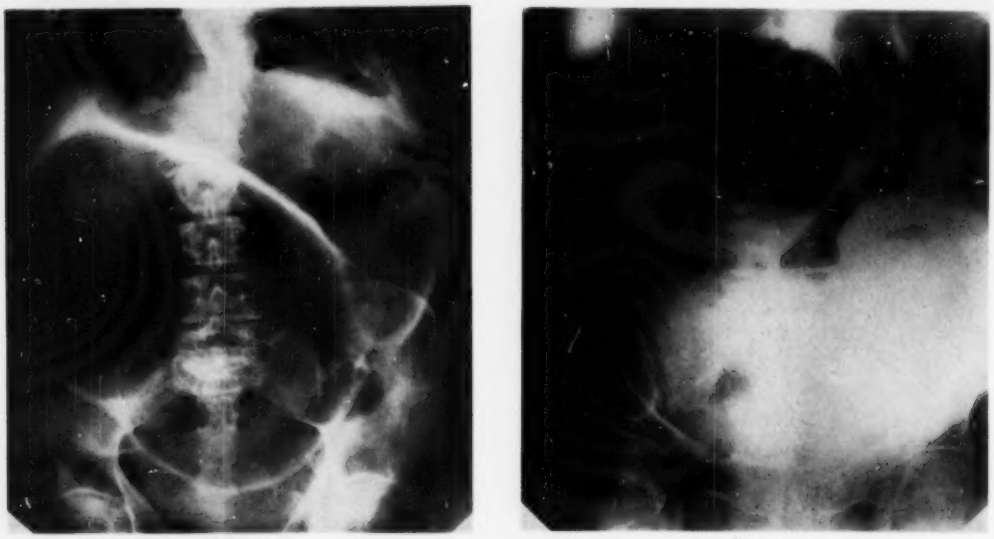
FIG. 658.—Mid small-bowel obstruction due to strangulation of a viable loop of small bowel through a hole in the falciform ligament. (Man aged 56 years.)

Supine

Erect

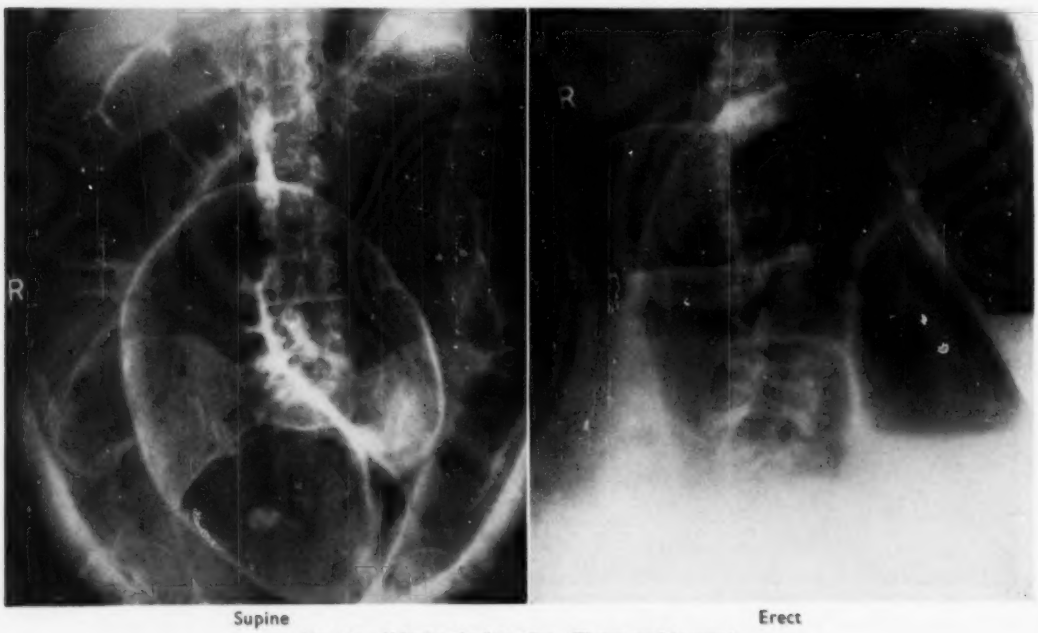
FIG. 659.—Acute large-bowel obstruction, due to a 'string' carcinoma of the pelvic colon. The ileocæcal valve has remained competent and there is no small-bowel distension. (Man aged 77 years.)

the typical findings in a mid-small-bowel obstruction due to strangulation of a viable loop of ileum through a hole in the falciform ligament. *Fig.* 659 shows the appearance of a large-bowel obstruction due to a carcinoma of the pelvic colon. The ileocæcal valve has remained competent, and there is no small-bowel distension. All radiographs in intestinal obstruction are not as easy to interpret as these. The giant cæcum due to simple obstruction of the transverse colon by a band, shown in *Fig.* 660, is easily mistaken for a volvulus of the pelvic colon (*Fig.* 661), which it only superficially resembles. *Fig.* 662 shows distension of both large and small bowel and an irregular arrangement of gas shadows



Supine Erect

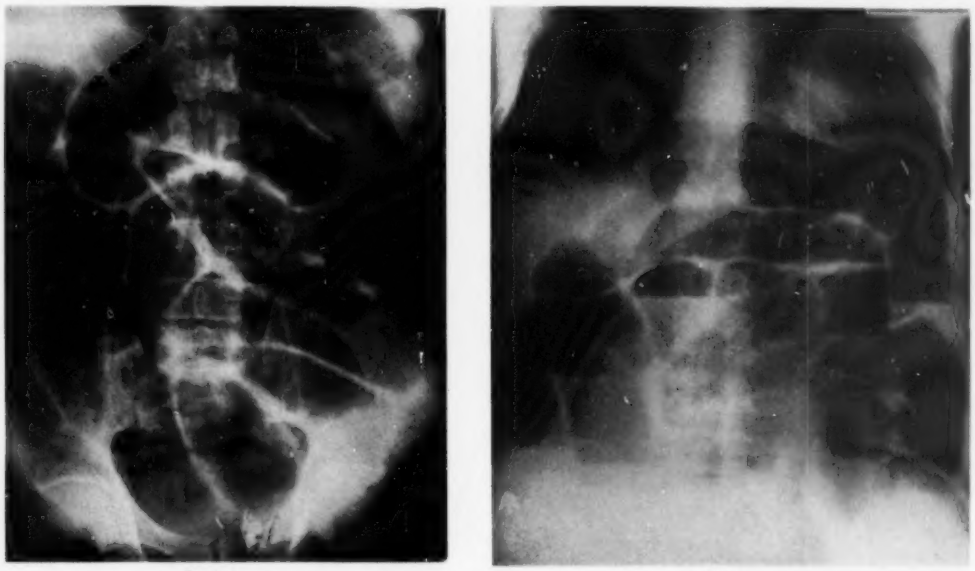
FIG. 660.—Giant cæcum due to simple occlusion of transverse colon by a band. (Man aged 78 years, with aortic incompetence and heart failure.)



Supine Erect

FIG. 661.—Volvulus of pelvic colon. (Woman aged 84 years.)

which defied accurate interpretation. At operation, this man of 66 years was found to have a complete volvulus of the small bowel through a complete turn about its mesenteric axis. He survived reduction



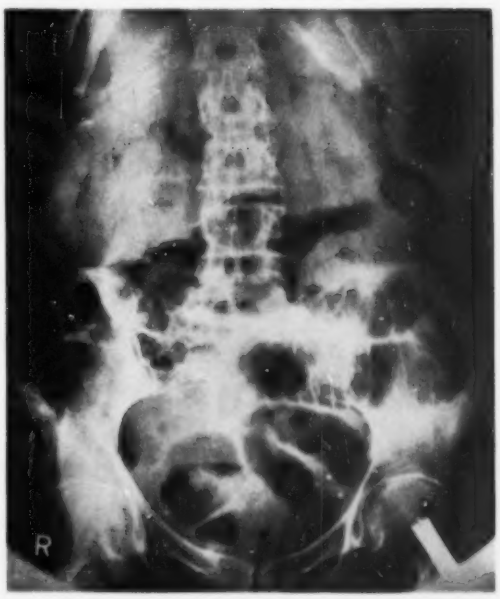
Supine Erect

FIG. 662.—Distension of both large and small bowel due to total volvulus of small bowel. (Man aged 60 years.)

of the twist. Occasionally straight radiographs of the abdomen are diagnostic. The presence of gas in the biliary tract in conjunction with loops of small bowel distended with fluid and gas, in a patient who has had no previous operation, indicates 'gall-stone ileus' (*Fig.* 663).

What is much less generally realized is that erect and supine radiographs may occasionally look normal or near normal in acute intestinal obstruction. *Fig.* 664 shows the radiographs of a patient who had been ill for over 24 hours, and who was later shown to have 6 ft. of gangrenous small bowel. There is no obvious distension of small bowel, and no fluid levels: nothing in fact to suggest the diagnosis. Similar findings have been observed in other cases of strangulation obstruction with gangrene of the small bowel. Always, at operation, in these cases, the explanation has been obvious. There is no distension of the small bowel above the level of the obstruction in these cases, either with fluid or with gas. It is as if the whole activity of the bowel, both motor and secretory, had ceased at the time of the strangulation, the only abnormality being a turgid gangrenous loop of small bowel, and much blood-stained fluid in the peritoneal cavity. Less often a simple occlusion of the small bowel may lead to distension of the bowel above the level of obstruction, with fluid but no gas. Presumably in these patients swallowed air gets no further than the stomach. Radiographs of the abdomen in such cases show only a uniform opacity similar to that seen in

ascites. *Fig.* 665 shows the radiographs of a patient with a low ileal obstruction due to an impacted gall-stone. She had fæculent vomiting at the time the radiographs were taken, and at operation the small

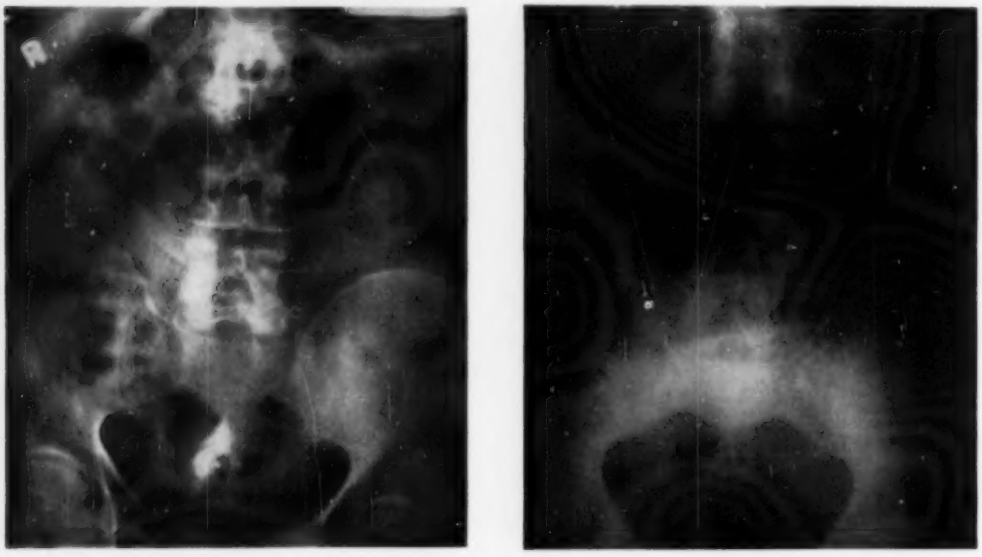


Supine

FIG. 663.—Gall-stone ileus. Note the gas in the biliary tract.

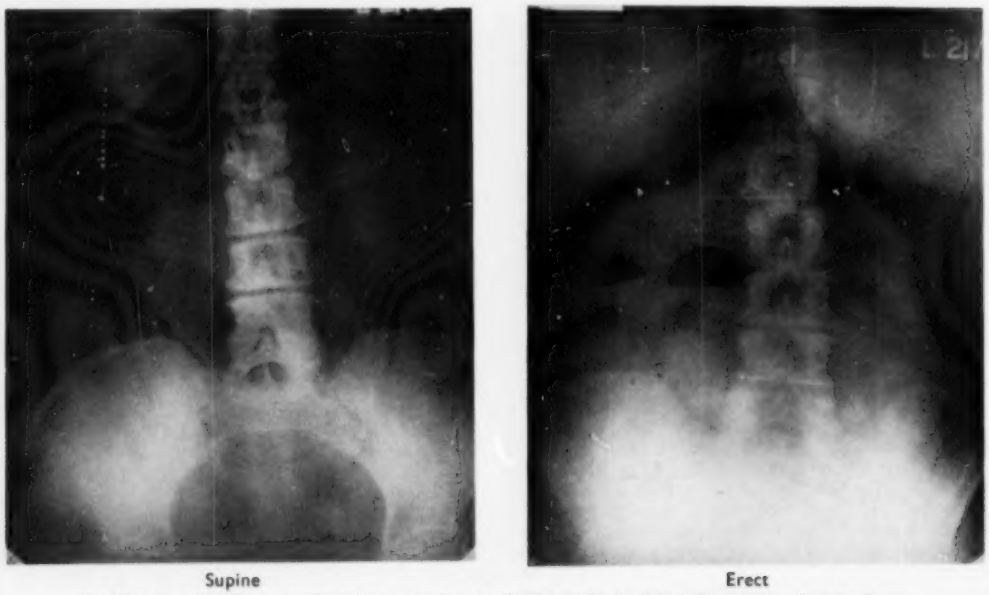
intestine was distended from the terminal ileum to the duodenojejunal flexure to 2–3 in. in diameter. It contained fluid but no gas. The radiographs show a uniform opacity and just three small fluid levels. The radiographs thus accurately mirror the pathological findings, and it is a misconception of the pathology rather than the radiographs which is at fault. How often do these 'false negative' radiographs occur in intestinal obstruction? Probably in not more than 5 per cent of cases.

Erect and supine radiographs are thus a useful and logical extension to the physical examination of



Supine Erect

FIG. 664.—Minimal distension of small bowel and no fluid levels in a man of 63 years, with 6 ft. of gangrenous small bowel due to strangulation obstruction by a band.



Supine Erect

FIG. 665.—Low ileal obstruction due to impacted gall-stone, showing minimal radiological appearances, in spite of gross distension of small bowel with fluid, but hardly any gas. (Woman aged 70 years.)

the abdomen by inspection, palpation, percussion, and auscultation. They are not, however, a 'short cut' which allows the diagnosis to be made, without seeing the patient, from the 'arm-chair'. No surgical centre can be said to be properly equipped to deal with intestinal obstruction unless erect and supine films of the abdomen can be obtained at all hours of the day and night, without unreasonable delay.

It is not enough just to diagnose the presence or absence of intestinal obstruction. In order to plan the subsequent treatment intelligently, we need to know if it is a large- or small-bowel obstruction. If it is a large-bowel obstruction we need to know if the cause is a carcinoma or a volvulus. If it is a small-bowel obstruction we want to know if the cause is a simple occlusion or a strangulation obstruction.

Little difficulty has been encountered in this series of cases in distinguishing between large- and small-bowel obstruction, and the cases of large-bowel obstruction due to volvulus have usually been diagnosed before operation. The diagnosis between simple occlusion and strangulation obstruction of the small bowel, on the other hand, has been found to be much more difficult. Severe and often continuous pain, accompanied by abdominal tenderness and sometimes palpable intestinal loops, which is later followed by abdominal rigidity, disappearance of bowel-sounds, and signs of circulatory collapse, is indicative of a strangulation obstruction. On the other hand, a long history (3–5 days), a relatively fit patient with considerable abdominal distension, obstructive bowel-sounds, and lack of abdominal tenderness and rigidity, does not necessarily mean that the cause is a simple occlusion. Three such cases have occurred in this series, two of which are briefly described.

Case 1.—Mr. E. F. (No. 5170), aged 68, had been an inmate of Friern Barnet Mental Hospital for 23 years, suffering from G.P.I., for which he had had a course of malarial treatment. Five days before admission he complained of colicky abdominal pain, vomiting, and constipation.

On examination he looked dehydrated and had fæculent vomiting. His temperature was 98° and pulse-rate 70. He had generalized abdominal distension, with a 'step-ladder' pattern, and visible small-bowel peristalsis. Bowel-sounds were active and high pitched and tinkling in character. There was no tenderness or rigidity. Supine and erect radiographs of the abdomen confirmed the presence of small-bowel obstruction.

A diagnosis of simple occlusion of the small bowel was made, and he was treated for 24 hours by gastroduodenal suction while his fluid and electrolyte depletion was corrected.

At operation (6 days after the onset of his illness) the cause of his obstruction was found to be a strangulated gangrenous loop of mid small bowel, caused by a band. The gangrenous loop was already disintegrating and lay in an abscess cavity containing intestinal contents. The wall of the cavity was formed by other surrounding loops of small bowel, adherent to each other, and to the gangrenous loop. The gangrenous loop was resected, and continuity of the bowel restored by end-to-end anastomosis. The abscess cavity was evacuated and all the adhesions broken down. The proximal distended small bowel was decompressed by multiple needle puncture and suction (Lowdon, 1951), and 1 mega unit of penicillin and 1 g. of streptomycin placed in the peritoneum before closing the abdomen. The wound healed by first intention, and convalescence was surprisingly uneventful.

Case 2.—Mrs. H. W. (No. B 19056), aged 82 years, had been attending the geriatric unit of the Whittington Hospital for a year, suffering from syphilitic aortitis, aortic incompetence, and heart failure. Five days before admission, she complained of colicky abdominal pain, vomiting, and diarrhœa. The diarrhœa lasted for only one day, but the other symptoms persisted and became more severe.

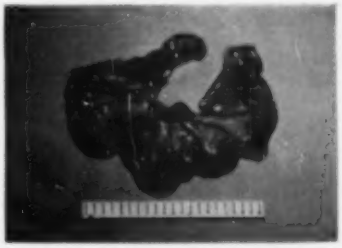


FIG. 666.—Disintegrating gangrenous loop of small bowel. *Case* 2.

On examination, she looked wasted and dehydrated. Her temperature was 98°, pulse-rate 90. The abdomen was grossly distended, and had a well-marked 'step-ladder' pattern; visible small-bowel peristalsis was present. There was no tenderness or rigidity, and rectal examination showed only distended bowel in the pouch of Douglas, without undue tenderness. Erect and supine radiographs confirmed the presence of small-bowel obstruction.

A diagnosis of simple occlusion of the small bowel was made, and 24 hours were spent correcting fluid and electrolyte deficiency.

At operation (6 days after the onset of the illness) a strangulated loop of terminal ileum, 6 in. in length, was found lying in the pelvis. The loop was not only gangrenous, but disintegrating, and had two perforations in it (*see Fig.* 666). It lay in an abscess cavity in the pouch of Douglas, which was walled off above by adherent loops of ileum. The loop was resected, and the small bowel decompressed (*see below*) and continuity of the bowel restored by end-to-end anastomosis. The abscess cavity was evacuated and all the adhesions broken down. One mega unit of penicillin and 1 g. of streptomycin were placed in the peritoneal cavity. She got over this operation well, and bowel-sounds returned on the fourth post-operative day. On the twelfth day she developed a bronchopneumonia and died two days later.

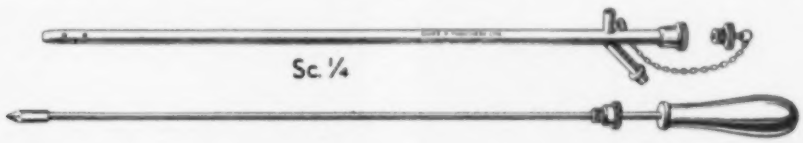


FIG. 667.—Savage's intestinal decompressor. The external diameter of the cannula is 5/16 in. The 'working length' of the cannula over which the bowel can be threaded is 14 in. Overall length 19 in.

Post-mortem examination confirmed the cause of death. There was no small-bowel distension and only minimal peritonitis.

It is sometimes quite impossible, therefore, to distinguish between simple occlusion and strangulation obstruction of the small bowel, until the abdomen is opened.

Treatment of Small-bowel Obstruction.—The treatment of acute small-bowel obstruction can properly be considered under the headings of correction of fluid, electrolyte, and blood-loss, intestinal decompression, and the relief of the obstruction.

FIG. 668.—The distended small bowel is encouraged to prolapse out of the abdomen.

In simple occlusion of the small bowel, with much vomiting, the need to replace both fluids and electrolytes is obvious, but the principles underlying this replacement are much too well understood to require any further comment by me. In strangulation obstruction, however, it is much less generally recognized how much blood can be lost from the circulation into the infarcted loop, and how much protein-rich blood-stained fluid into the peritoneal cavity. It is this loss of whole blood and fluid from the circulation which leads to the circulatory collapse in the early stages of strangulation obstruction, and not to the absorption of any hypothetical toxin from the obstructed loop into the blood-stream. Rapid blood transfusion thus plays an essential part in the resuscitation of these patients, and it is a good working rule that they will require about a pint of blood for every 1–2 ft. of infarcted bowel.

It profits a patient but little if in spite of adequate replacement of fluid and electrolyte loss, and removal of the cause of his obstruction, he dies with paralytic ileus from unrelieved overdistension of his bowel. At the beginning of this series an extensive trial of Miller-Abbott intubation (Miller and Abbott, 1934; Abbott and Johnston, 1938; Johnston, Penberthy, Noer, and Kenning, 1938; Wilson, 1938; Penberthy, Johnston, and Noer, 1939; Abbott, 1941) was made in all those patients who had gross abdominal distension and were deemed to be suffering from a simple occlusion rather than a strangulation obstruction. Whilst, given time, little difficulty was

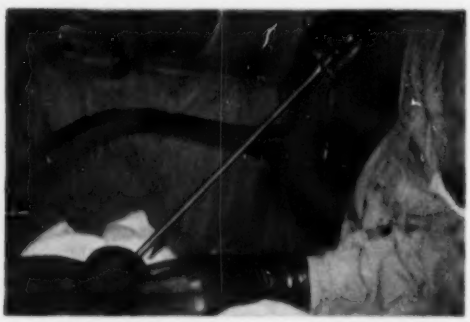


FIG. 669.—The decompressor is introduced into the bowel a few inches above the site of the obstruction.

FIG. 670.—As soon as the decompressor is introduced, it empties the loop by means of the lateral holes in the cannula, placed behind the trocar point.

FIG. 671.—The trocar is removed and discarded, and the end of the cannula closed by the screw plug.

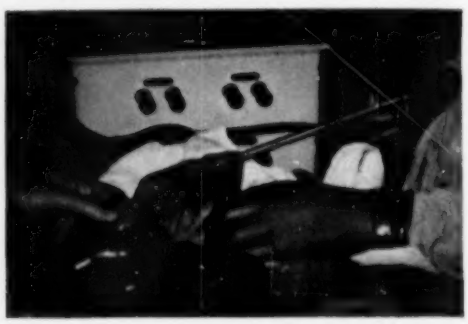


FIG. 672.—The distended small bowel is then threaded over the decompressor, like a curtain over a curtain rod.

FIG. 673.—Strange as it may seem, the whole of the small bowel can be threaded over the 14 in. of the working length of the decompressor.

FIG. 674.—The opening in the small bowel is closed in two layers with interrupted 00 silk sutures at right angles to the long axis of the bowel.

FIG. 675.—The ease with which the peritoneum can be closed after intestinal decompression is well shown.

FIG. 676.—The abdomen—before operation 33½ in. in circumference.

FIG. 677.—The abdomen—after operation 30 in. in circumference.

FIG. 678.—One and a half litres of fluid and an unmeasured volume of gas have been removed from the small bowel.

encountered in passing the tube in the unobstructed patient, it was found to be almost impossible in those with fæculent vomiting. In some of those in whom it was successfully passed, it proved a very slow method of emptying the bowel. On occasions the tube became blocked and had to be removed. In confused senile patients it was usually badly tolerated, and often pulled out by the patient, who "could stand it no longer". Even in those who did tolerate it, it often so much interfered with coughing that it produced pulmonary collapse and rendered the patient less fit for operation. The risk of stricture of the œsophagus is also a very real one, especially in old patients with hiatus hernia (McCredie and McDowell, 1958; Bingham, 1958; McKeown, 1958). Perhaps the greatest danger of Miller-Abbott intubation is the delay it causes in operation (Cooke, 1958). If you believe, as I do, that it is impossible to be quite sure that an obstructed patient has not got a strangulation as opposed to a simple small-bowel obstruction, then this delay becomes quite unjustifiable.

It is advocated, therefore, that patients with small-bowel obstruction be taken to the operating theatre just as soon as they can be made fit for operation; that the stomach be properly emptied with a large-bore stomach tube in the anæsthetic room to minimize the risk of inhalation of vomit during the induction of the anæsthetic; and that

decompression of the small bowel be carried out transabdominally at the same time that the cause of the obstruction is relieved.

There is nothing new about emptying the obstructed small bowel either by multiple needle puncture (Lowdon, 1951) or by enterotomy (Vandenburgh, 1920; Moynihan, 1926; Holden, 1926; Cheever, 1932; Wangensteen, 1942). Multiple needle puncture and suction sometimes works well if the bowel is distended mostly with gas, but can be exasperatingly inefficient if the bowel contains fluid and much particulate matter. After much experiment both in the post-mortem room and the operating theatre, the intestinal decompressor (Savage, 1958) shown in *Fig.* 667 was evolved. Suction is applied by means of the angled side-arm. The distended small bowel is allowed to prolapse out of the abdomen, and, after relieving the cause of the obstruction, the trocar end of the instrument is introduced into the lumen of the distended small bowel just above the level of the obstruction. The trocar is then withdrawn and discarded, and the end of the instrument closed with the screw plug. The intestine is then threaded over the instrument in much the same way that curtain is threaded over a curtain rod, the degree of suction applied being regulated by a thumb placed over the side vent. Surprising though it may seem, it is quite possible to thread the whole of the small bowel over the 14 in. of the working length of the instrument. That the whole of the small bowel could be so treated was first noted many years ago (Monks, 1903), to be 'rediscovered' independently by the author fifty-two years later. At the end of the decompression the hole in the small bowel is closed in two layers with 00 interrupted silk sutures placed at right angles to the long axis of the gut (*see Figs.* 668–678). The intestinal decompressor has been in use for just over five years, and has now been used 51 times. It has proved to be a very quick and effective way of emptying the small bowel, with little or no contamination, not only in cases of small-bowel obstruction, but also in cases of large-bowel obstruction with an incompetent ileocæcal valve, and small-bowel distension. In these cases the decompressor is introduced into the terminal ileum a few inches from the ileocæcal valve. After the small bowel has been emptied, it is turned round and passed through the ileocæcal valve and the cæcum and ascending colon are also emptied. It has also proved of great value in decompressing the small bowel in late cases of acute appendicitis with generalized peritonitis and intestinal distension from paralytic ileus. Among the more immediate advantages of its use are the ease with which the abdomen can be closed at the end of the operation, and the freedom of diaphragmatic movement in the immediate post-operative period. If the stomach is emptied before operation, inhalation of vomit during recovery from the anæsthetic becomes virtually impossible. It has been argued, against the use of this decompressor, that the handling of the bowel during decompression results in a prolonged period of post-operative paralytic ileus, and that the bowel soon becomes filled again with fluid and gas. This has not been my experience, and with the bowel empty and the cause of the obstruction removed, the return of bowel-sounds can be confidently expected during the next 2–4 days, during which time the patient's fluid and electrolyte requirements should be given intravenously.

Table VII.—Operative Procedures used in the Management of 122 Cases of Small-bowel Obstruction

	No. of Times used
Division of bands and adhesions	55
Division of bands and evacuation of pus	8
Reduction of intussusception	7
Reduction of volvulus	4
Removal of gall-stones	2
Entero-entero anastomosis	10
Resection and end-to-end anastomosis of small-bowel	29
Ileocæcal resection and end-to-end anastomosis	5
Right hemicolectomy and end-to-end anastomosis	2
Intestinal decompression	35

Table VIII.—Primary Operative Procedures used in 57 Cases of Large-bowel Obstruction

	No. of Times used
Proximal 'Ostomy':—	
Cæcostomy	1
Loop transverse colostomy	25
Loop left inguinal colostomy	5
Witzel cæcostomy	2
Witzel transverse colostomy	1
Anastomosis:—	
Ileotransverse anastomosis	3
Ileosigmoid anastomosis	1
Primary Resection:—	
Hartman's operation	1
Paul-Mickulicz operation	1
Primary resection and end-to-end anastomosis	10
Right hemicolectomy	4
Transverse colectomy	1
Pelvic colectomy	4
Resection of splenic flexure	1
Other Procedures:—	
Reduction of colocolic intussusception	1
Untwisting of volvulus	3
Sigmoidoscopic decompression	4
Division of adhesions	3

The procedures used in relieving the cause of the obstruction in 122 cases of small-bowel obstruction are shown in *Table VII.* In patients under the age of 70 years, resection and end-to-end anastomosis for gangrenous small bowel carried no higher mortality than division of adhesions or entero-entero anastomosis. It is thus pertinent to inquire whether immediate resection and end-to-end anastomosis, as opposed to a short-circuit operation, is a safe procedure in cases of small-bowel obstruction due to regional ileitis or carcinoma of the cæcum and ileocæcal valve obstruction. I believe that it is, provided the gut proximal to the obstruction is decompressed and the patient's general condition permits. In this series 4 children under the age of 1 year required a resection because of a gangrenous ileocolic or ileocæcal intussusception. In each case the operation was concluded by an immediate ileocolic anastomosis. All recovered, and it is considered that the Paul-Mikulicz type of two-stage operation (Woodall, 1938; Ladd and Gross, 1934; Gross, 1953; Jones, 1953) is not necessary. There were no cases of neonatal obstruction in this series.

Treatment of Large-bowel Obstruction.—Most cases of uncomplicated carcinoma of the colon are now treated by radical resection and immediate end-to-end anastomosis. Is immediate resection and end-to-end anastomosis of the colon safe in the presence of obstruction? In this series it has been

carried out 10 times, in carefully selected cases, without mishap (*see Table VIII*). I believe that it is safe provided the obstruction is not too gross, the bowel proximal to the obstruction is decompressed, and the anastomosis is carried out carefully using two layers of interrupted silk sutures. The method is much more easily applicable to growths in the right half of the colon than the left (Goligher and Smiddy, 1957). In growths of cæcum ascending and transverse colon it is now regarded as the treatment of choice even in curable cases, and the fear that it would not be possible to carry out a radical resection in the presence of obstruction has proved unfounded (*see Figs.* 679, 680). In fact, it is much easier to carry out a radical resection in the presence of obstruction than it is after a first-stage ileotransverse anastomosis to relieve the obstruction. After an ileotransverse anastomosis the anastomosis usually becomes adherent to the root of the ascending mesocolon, making identification of the origins of the ileocolic, right colic, and middle colic arteries difficult. For this reason it is suggested that if the patient is not fit for an immediate right hemicolectomy, the obstruction should, if possible, be relieved by a cæcostomy rather than by an ileotransverse anastomosis.

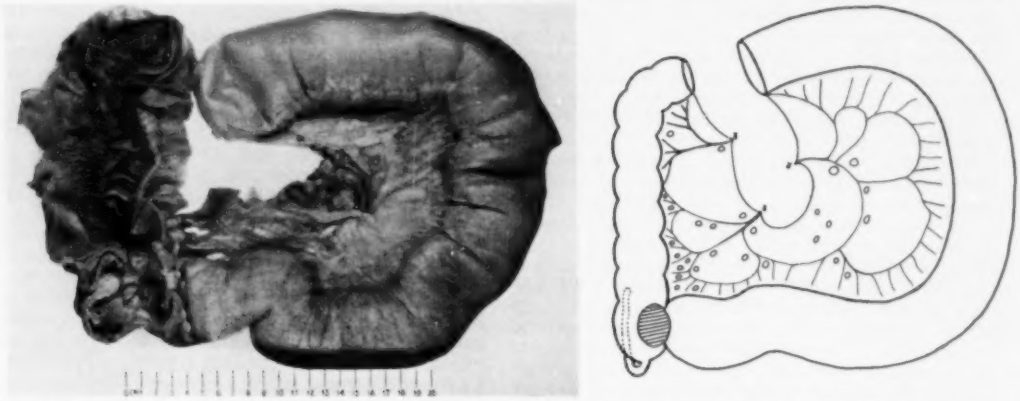


FIG. 679.—Emergency right hemicolectomy and end-to-end anastomosis for carcinoma of cæcum and acute on chronic ileocæcal valve obstruction. There are no secondaries in 28 charted lymph-nodes. (Man aged 78 years.)

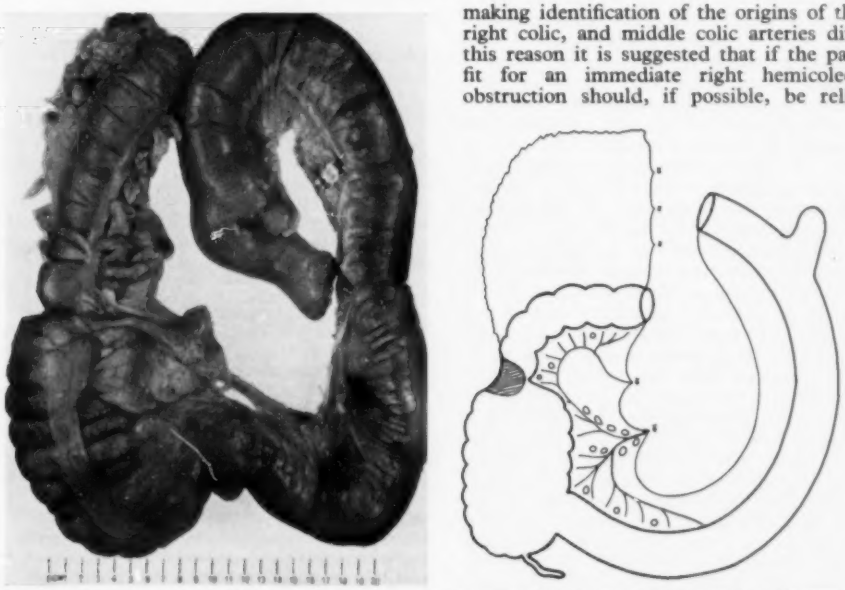


FIG. 680.—Emergency right hemicolectomy and end-to-end anastomosis for carcinoma of ascending colon with acute obstruction. The ileocæcal, right colic, and right branch of the middle colic artery have all been ligated at their origin, and there are no secondaries in 14 charted lymph-nodes. (Woman aged 82 years.)

In obstruction by 'curable' growths of the left side of the colon immediate resection and end-to-end anastomosis has little if any place. A 'radical operation' for such growths requires that the inferior mesenteric artery be ligated flush with the aorta,

which means than an 'open' type of anastomosis, at least as low as the promontory of the sacrum, will have to be carried out. Even after efficient emptying of the colon, such an operation is likely to cause some fæcal contamination. In these cases the obstruction is much better treated by a simple loop transverse colostomy, placed as near to the hepatic flexure as possible. The radical left hemicolectomy can then be carried out as a planned procedure in a fit patient with an empty bowel. The transverse colostomy is closed as a third-stage operation by dissecting it free from the abdominal wall, resecting it, and restoring the continuity of the bowel by end-to-end anastomosis.

In patients with obstructing growths of the left side of the colon and secondaries in the liver or peritoneum the position is very different. Their expectation of life is short, and they should not have to spend the first six weeks of their remaining span having a three-stage resection. A limited resection only is required, without removal of the lymphatic field, and with growths of the transverse descending and pelvic colon this is often easily carried out in the presence of obstruction. Patients with obstructing growths of the upper one-third of the rectum and rectosigmoid are better treated by a three-stage resection even if there are secondaries.

Of the 43 cases of large-bowel obstruction due to carcinoma, the growth was not resected in only 6 cases. Three of these died after the first-stage operation; 2 had extensive secondaries, and 1 died from a pulmonary embolus. Two of the other 3 cases had massive carcinomata of the middle and lower one-third of the rectum, with secondaries in the liver. As they would be left with a colostomy in any case, palliative abdominoperineal excision was not advised. The third patient had a carcinoma of the pelvic colon and multiple secondaries, for which a transverse colostomy was carried out. She elected not to have the growth removed and the colostomy closed.

Large-bowel obstructions due to causes other than carcinoma form an interesting if therapeutically unrewarding group of cases. Of the 14 cases, 8 were over the age of 80 years and another 5 over 70. A mortality of 36 per cent is thus not surprising. Half the cases suffered from volvulus of the pelvic colon. It is usually possible, with the aid of erect and supine radiographs of the abdomen, to diagnose this condition, and to decompress the distended pelvic colon by passing a large-bore stomach tube through a sigmoidoscope up into the pelvic colon (Tanner, 1927). If this manœuvre is successful the patient should be prepared for a formal resection of the pelvic colon, as it is quite certain that the volvulus will recur if this is not done. Even if the volvulus is untwisted by operation, it is likely to recur, as happened in the only 2 cases treated by this method in this series. The second time, both these cases were treated by immediate resection and end-to-end anastomosis, after emptying the distended colon by a stomach tube per anum by an assistant, and guided by the surgeon up into the transverse colon (Lowdon, 1951). Both recovered.

SUMMARY

1. One hundred and seventy-nine cases of acute intestinal obstruction, with a mortality of 15 per cent, are reviewed. In the 109 cases under the age of 70 years the mortality was only 6·5 per cent.

2. The value of erect and supine radiographs as an aid to the diagnosis is stressed, and some of the pitfalls in interpretation discussed.

3. The disadvantages of pre-operative Miller-Abbott decompression of the distended small bowel are discussed, and an alternative method of operative small-bowel decompression advocated.

4. The place of immediate resection and end-to-end anastomosis in large-bowel obstruction is discussed.

Acknowledgements.—It is a pleasure to thank Mr. Hermon-Taylor, Mr. E. I. Butler, Mr. J. E. Richardson, and the late Mr. George Neligan, of the London Hospital, and Mr. J. Scholefield, of the West Middlesex Hospital, for allowing me to treat cases admitted under their care, and to include them in this series. Thanks are due to Dr. Rinsler for the colour photographs of the operative intestinal decompression; to Miss Mason, of the photographic department of St. James's Hospital, Balham, for the X-ray reproductions; Mr. E. G. Rhodes and Mr. G. W. A. Moore, senior technicians in the Department of Pathology, for the photographs in *Figs.* 679, 680. The intestinal decompressor was made by Chas. F. Thackray, Ltd., Park Street, Leeds, 1.

REFERENCES

ABBOTT, W. O. (1941), *N. Engl. J. Med.*, **225**, 641.
— — and JOHNSTON, C. G. (1938), *Surg. Gynec. Obstet.*, **66**, 691.
ASSMAN, H. (1913), *Dtsch. Z. Nervenheilk.*, **1**, 47.
BINGHAM, J. A. W. (1958), *Brit. med. J.*, **2**, 817.
CASE, J. T. (1928), *Amer. J. Roentgenol.*, **19**, 413.
CHEEVER, D. (1932), *N. Engl. J. Med.*, **207**, 1125.
COOKE, R. V. (1958), *Proc. R. Soc. Med.*, **15**, 508.
DAVIS, K. S. (1927), *Amer. J. Roentgenol.*, **17**, 543.
GOLIGHER, J. C., and SMIDDY, F. G. (1957), *Brit. J. Surg.*, **45**, 272.
GROSS, R. E. (1953), *Surgery of Infancy and Childhood*, 292. Philadelphia and London: W. B. Saunders Co.
HOLDEN, W. B. (1926), *Arch. Surg., Chicago*, **13**, 885.
JOHNSTON, C. G., PENBERTHY, G. C., NOER, R. J., and KENNING, J. C. (1938), *J. Amer. med. Ass.*, **111**, 1365.
JONES, J. D. T. (1953), *Brit. med. J.*, **11**, 1304.
LADD, W. E., and GROSS, R. E. (1934), *Arch. Surg., Chicago*, **29**, 368.
LOWDON, A. G. R. (1951), *Lancet*, **1**, 1103, 1104.
MCCREDIE, J. A., and MCDOWELL, R. E. C. (1958), *Brit. J. Surg.*, **46**, 260.
MCKEOWN, K. C. (1958), *Brit. med. J.*, **2**, 219.
MILLER, T., and ABBOTT, W. O. (1934), *Amer. J. Med.*, **187**, 595.
MONKS, G. H. (1903), *Ann. Surg.*, **38**, 581.
MOYNIHAN, B. (1926), *Abdominal Operations*, vol. I, 490. Philadelphia and London: W. B. Saunders Co.
OCHSNER, A., and GRANGER, A. (1930), *Ann. Surg.*, **92**, 947.
PENBERTHY, G. C., JOHNSTON, C. G., and NOER, R. J. (1939), *Sth. Surg.*, **8**, 416.
RABWIN, M. H., and CARTER, R. A. (1930), *Calif. West Med.*, **33**, 483.
SAVAGE, P. T. (1958), *Proc. R. Soc. Med.*, **15**, 508.
SMITH, R. (1948), *Acute Intestinal Obstruction*, 4. London: Arnold.
TANNER, W. E. (1927), *Clin. J.*, **56**, 493.
VANDENBURG, H. J. (1920), *J. Mich. med. Soc.*, **19**, 67.
WANGENSTEEN, O. H. (1942), *Surg. Gynec. Obstet.*, **75**, 675.
WILSON, D. M. (1938), *Proc. Mayo Clin.*, **13**, 666.
WOODALL, B. (1938), *Arch. Surg., Chicago*, **36**, 989.

THE RELIABILITY OF TELEPAQUE CHOLECYSTOGRAPHY

By D. A. ALDERSON

X-RAY DEPARTMENT, KING'S COLLEGE HOSPITAL MEDICAL SCHOOL, DENMARK HILL, LONDON, S.E.5

SINCE the introduction by Graham and Cole in 1924 of tetra-bromphenolphthalein as a cholecystographic medium cholecystography has become accepted as a valuable aid in the diagnosis of gall-bladder disease. Its accuracy has been demonstrated by several writers, increasing generally with improvements in the medium used, first, by the substitution of iodine for bromine (tetra-iodophenolphthalein, T.I.P., Opacol, Cholotrast) (Whittaker, Milliken, and Vogt, 1925) and, secondly, by the use of an iodine-containing derivative of phenylpropionic acid (iodoalphionic acid, Pheniodol, Priodax, Bilitrast) (Dohrn and Diedrich, 1940). The work of Lewis and Archer (1949) led to the introduction in 1951 of iodopanoic acid (Telepaque), which was favourably compared with the earlier media, both in regard to its diagnostic value and its lack of side-effects (Christensen and Sosman, 1951; Dunne, Jensen, and Hughes, 1951, 1953; Scott and Simril, 1951; Morgan and Stewart, 1952; Spencer, 1952; Stevenson, 1952; Whitehouse and Martin, 1953).

There are, however, few authors who have correlated the cholecystographic findings, using telepaque, with the surgical and pathological findings (Mauthe, 1954; Whitehouse, 1955; Stenhouse, 1956; Baker and Hodgson, 1959) as was done for the earlier media (T.I.P.: Kirklin, 1933; McWhirter, 1935; and pheniodol: Smith, and Runge, 1951; Russo and Cavanagh, 1952; Martin and Massimiano, 1952; Gordon, 1953; Baker and Hodgson, 1958; Morales and Svedberg, 1949; Wickbom and Rentzhog, 1953). The present paper is based on the findings at operation over the past six years at King's College Hospital. For inclusion, each case satisfied these criteria: that the cholecystogram should have been performed at King's College Hospital using telepaque with the technique described below and that the full operative and pathological findings should be available. Cases satisfactory in these respects totalled 315 and are analysed below.

Procedure for Telepaque Cholecystography.—The patient takes 3 g. of telepaque with water at 9 p.m. before examination, after a light supper from which all fats are omitted as far as practicable. In the morning, he reports at 9 a.m. in a fasting state. Two films, 12 in. by 10 in. (30·5 × 25·4 cm.), are then taken of the gall-bladder area, one prone oblique and one erect. These films are examined and if no gall-bladder shadow is visible the procedure is repeated over the next day, unless the medium has been vomited, has not been ingested, or has been held up in the stomach or œsophagus. If the gall-bladder is visible, a fatty meal of eggs and milk is given and further films taken after 20 min.

Method of Analysis.—The case notes and radiological reports were studied of all patients undergoing cholecystectomy at King's College Hospital in the years 1953 to 1958. The pathological diagnosis and the findings of stones at operation or in the resected specimen were noted. Histologically a diagnosis of chronic cholecystitis was made only if there was fibrosis of the wall. Infiltration of the wall by scattered and focal collections of chronic inflammatory cells or patchy superficial ulceration of the membrane without mural fibrosis were not considered as indicative of chronic cholecystitis.

The radiological reports described the gall-bladder concentration of telepaque as nil, or faint, moderate, or good, approximately according to whether the density of its shadow was less than, equal to, or more than that of the liver. The presence of stones was noted.

RESULTS

The correlation between the radiological reports and the operative and pathological findings is given in *Table I*. In the 315 cases, there are 3 errors of diagnosis—one in which two stones were not observed in a normally concentrating gall-bladder, a second in which concentration was reported as being less than normal in a gall-bladder subsequently shown to be normal, and one case of a normally concentrating gall-bladder which was found to show cholesterosis.

Table I.—CORRELATION OF RADIOLOGICAL REPORTS AND PATHOLOGICAL FINDINGS

	Concentration of Telepaque			
	Nil	*Poor*	*Moderate*	*Good*
Pathological Findings:—				
Cholecystitis without stones:—				
Chronic	19	5	2	
Chronic with liver cirrhosis	1			
Acute	1			
Cholesterosis	1		2	1
Cholecystitis with stones:—				
Chronic	84	28	12	7
Cholesterosis				3
Stones without cholecystitis:—	15	26	34	54
With mucocœle	7			
With carcinoma	1			
With polycystic liver		1		
With cirrhosis			1	
Normal	0	1	0	9
Total	129	61	51	74
Stones—total	107	55	47	64
Stones—observed	44	50	45	63
Stones—not seen	63	5	2	1

Review of the films in the case in which two stones were missed shows that they were, in fact, demonstrated, one being about 1 cm. in diameter. This examination took place at the time of transition from pheniodol to telepaque, and examination with pheniodol a week before had failed to demonstrate the stones.

In the second case, the report of poor concentration is not justified in retrospect. The density of the gall-bladder is, in fact, greater than that of the liver.

Three errors in 315 diagnoses gives an overall accuracy of 99·0 per cent, which compares with 99·2 per cent in the 124 cases described by Whitehouse (1955). Stenhouse (1956) is of the opinion that 1 case in 10 showing no gall-bladder shadow is found at operation to have a normal gall-bladder, quoting a series of 55 with no shadow after telepaque, of which 5 were found to have normal

gall-bladders. Two of these, however, had pyloric stenosis and another a tumour of the head of the pancreas involving the common bile-duct. On the other hand, he found 100 per cent accuracy in the demonstration of stones with telepaque. Mauthe (1954), in a mixed series of telepaque and pheniodol, had 5 errors in 110 operated cases—95·5 per cent accuracy. He summarizes his views in saying that the method "practically never fails to reveal pathology when this is present and that to proceed to cholecystectomy in the face of a normal cholecystogram is difficult to justify".

Comparison with Earlier Media.—Baker and Hodgson (1958) reviewed a large series of cholecystograms with priodax (pheniodol). In 1223 diagnoses they found 2·7 per cent errors. They have analysed their results to show the accuracy of each type of report.

Where *stones or tumours* were diagnosed only 6 such diagnoses out of 667 were incorrect—0·9 per cent. In my series, stones were found in all 202 cases in which they were reported.

Their diagnosis of *poor function*, i.e., without visible stones, in 22 cases included 2 errors. The comparable figure for this series is 1 error in 7 diagnoses.

For *non-functioning gall-bladders* their figure of 9 errors in 270 compares with 0 in 85.

Among 260 gall-bladders reported as *normally functioning* by them, 9 contained stones and 7 showed evidence of chronic inflammation. In 11 gall-bladders reported as normal in this series, 1 contained a stone and 1 showed signs of cholesterosis.

While the two series have a similar order of accuracy, it is of interest that they found chronic cholecystitis in only 37 cases but cholelithiasis in 912, and that no cases are reported of stones and chronic inflammation together; whereas in my series there are 27 cases of chronic cholecystitis, 129 of cholelithiasis, and no less than 131 in which both were found. The same authors (1959) in a similar series with telepaque have found their results to be comparable to those with pheniodol.

The errors reported with telepaque and pheniodol are shown in *Tables II* and *III*.

Table II.—ERRORS OF DIAGNOSIS USING TELEPAQUE

	1. *Stones*	2. *Poor function*	3. *Non-functioning*	4. *Normal*
Whitehouse (1955)	0 in 68	0 in 6	0 in 50	1 in 1
Stenhouse (1956)			3 in 55	
Mauthe (1954)				3 in 14
Present series	0 in 202	1 in 17	0 in 85	2 in 11

Table III.—ERRORS OF DIAGNOSIS USING PHENIODOL

	1. *Stones*	2. *Poor function*	3. *Non-functioning*	4. *Normal*
Gordon (1953)	0 in 36	0 in 7	1 in 24	6 in 19
Russo and Cavanagh (1952)		0 in 7	1 in 65	
Martin and Massimiano (1952)	5 in 145		5 in 73	3 in 14
Baker and Hodgson (1958)	6 in 667	2 in 22	9 in 270	16 in 260
Smith and Runge (1951)	1 in 118		0 in 50	16 in 112

Fallibility of the Method.—

1. *Stones reported.*—There is a general agreement that where stones are reported radiologically the accuracy of the report is extremely high. This is of considerable surgical importance, as it has been pointed out by Cole and Grove (1952) that when stones are found, cholecystectomy gives a satisfactory result in more than 90 per cent of cases. This has recently been confirmed by Burnett and Shields (1958).

No incorrect diagnosis of stones has been reported with telepaque by those authors who have given pathological findings. This was also confirmed by Park (1957) in his address to the B.M.A. Section of Radiology and Surgery when he said that, if the gall-bladder is filled, no calculi are undiagnosed by telepaque.

Some authors, while agreeing that the diagnosis of cholelithiasis with telepaque is accurate, claim that the increased density of the shadow may, in fact, obscure small concretions (Sutton and Tillett, 1954; Lodge, 1955; Jefferson, 1957; Kerley, 1958; Zimmer, 1958). It seems that this bogy is not of great practical significance, only 1 stone being missed in this series in 64 normally concentrating gall-bladders; one which was, in fact, shown but overlooked. In this respect, the films taken erect and after the fatty meal are most useful (Levene and Scheff, 1957). The film taken in the erect position will frequently show small stones as a horizontal layer.

2. *Poor or Nil Concentration.*—The accuracy of the diagnosis of disease when the concentration is nil or less than good, in the absence of demonstrable stones, has been the subject of controversy. Wickbom and Rentzhog (1955) say that non-filling or poor filling is almost always conclusive of disease. In this series this diagnosis was inaccurate in only 1 case in 102. Aldridge (1956) lists fourteen causes of 'non-visualization' besides gall-bladder disease, but, as Wise (1957) has pointed out, "one is not justified in making a diagnosis of gall-bladder disease from radiographs alone. It is only presumptive evidence and must be related to clinical history and investigation as to whether the tablets have been taken, vomited, or passed."

With telepaque, in practice, the quoted disadvantage that there are unabsorbed residues of telepaque in the bowel which may obscure the gall-bladder (Gordon, 1953; Lodge, 1955; Jefferson, 1957; Schaaf and Wilhelm, 1957; Seedorf and Powell, 1958) turns out to be an advantage, because the residues prove that the tablets have been taken and have passed through the small intestine (Rogers, Bonmati, Leigh, and Gay, 1953; Mitchell, 1956; Johnson, 1957; Reynolds and Fulton, 1958).

Gordon's well-known dictum (1953) that with complete failure of concentration the chances are 20 to 1 on disease and with poor concentration 6 to 1 on disease now appears rather pessimistic. Kerley (1958) is emphatic that "if the gall-bladder shadow is absent after proper technique, either the cystic duct is obstructed or the mucosa cannot concentrate, so that the gall-bladder is a surgical one".

Mauthe (1954), discussing telepaque cholecystography, finds that it is practically "without error when applied to the pathological gall-bladder".

3. *Normal Gall-bladder reported.*—It has been stated (Good, 1958; Gray, 1958) that the increased density of the shadow with telepaque would lead to a high incidence of gall-bladders being reported as normal which were, in fact, diseased. This appears to be a possible source of error. While in this series only

2 gall-bladders reported as normal were found at operation to be diseased, there were also 7 cases in which chronic cholecystitis was found, together with the reported stones, although the concentration of medium had been good. The presence of chronic cholecystitis with mucosal destruction is, therefore, masked on occasion by the density of the medium. In this series this has not been found in the absence of stones.

From *Table I* it will be seen that where there is chronic cholecystitis and stones the concentration tends to be nil or poor, and that where stones are found without inflammation the concentration is more often moderate or good. This confirms that the degree of density of telepaque is some index of the function of concentration (Gordon, 1953; Graham, 1954; Esguerra-Gómez, 1957). Probably the danger of the greater density occasionally obscuring mucosal damage or small concretions is of lesser importance than the advantages of demonstrating stones more frequently (Jefferson, 1957) and of reducing the number with doubtfully poor concentration (Morgan and Stewart, 1952; Stevenson, 1952; Whitehouse, 1955).

Mauthe (1954) has stated that the cholecystographic findings are practically never normal in the presence of significant gall-bladder disease, whether stones, cholecystitis, or carcinoma. Certainly none of the reported series using telepaque confirms Rose's statement (1958) that "a normal classical cholecystographic report on a patient suffering from symptoms which implicate the biliary tract is incorrect in 95 per cent of cases".

Baker and Hodgson (1958), in a detailed analysis of the errors in 'normal' gall-bladders (16 in 260), consider that about half are unavoidable, where the stones are very small or where some degree of inflammation is present. In the remainder, improved technique, particularly in observation of the cystic duct, would eliminate error. A hard core of unavoidable error, therefore, of about 3 per cent remains in normal cholecystogram reports.

Lodge (1955) has said that good concentration in middle-aged and elderly people is not to be regarded as excluding biliary disease unless followed by adequate contraction and emptying. It is difficult to accept this because a gall-bladder which does not empty is hardly likely to be able to concentrate. One must agree rather with Shapiro (1954) that no disease should be diagnosed on a delayed response to a fatty meal, but that instead the fatty meal is used to increase the chance of demonstrating small stones in a lesser volume.

CONCLUSIONS

It appears that oral cholecystography with telepaque is an accurate aid in the diagnosis of gall-bladder disease. Sutton (1957) has recommended that, because the dose of telepaque absorbed is unpredictable and because some patients suffer toxic effects from it, intravenous biligrafin should be used instead for routine examination. This technique, however, is costly, cumbersome, and time consuming, and should properly be reserved for those cases in which the concentration of telepaque is less than normal or in which the ducts have not been adequately demonstrated.

It is, in fact, complementary to telepaque, with separate indications for its use (Mosca and Scavino, 1957). It should also be pointed out that reactions to biligrafin are appreciable in incidence. Kremens, Berger, and Cohn (1956) report a case of peripheral vasomotor collapse, saying that their original estimate of its usefulness is tempered by a sound regard for the occasional reaction encountered. Goldenberg and Kummer (1958) quote Pendergrass as reporting 2 deaths due to its use.

Intravenous biligrafin is recommended by Aldridge (1956) for use after cholecystectomy, for pre-operative cholangiography, following unsuccessful oral cholecystography, for infants, children, and in emergency, where there is a tumour near the porta hepatis or after recent jaundice. He confirms that telepaque is the oral medium of choice and should in the ordinary way be used first.

SUMMARY

The operative and pathological findings at cholecystectomy in 315 patients who had had cholecystograms performed with telepaque are compared with the radiological reports. The accuracy of the reports was 99·0 per cent. The results with telepaque compare favourably with those using earlier media. Oral cholecystography with telepaque is held to be the most satisfactory routine radiological investigation of gall-bladder symptoms.

Acknowledgements.—I wish to thank the Surgical Staff of King's College Hospital for permission to use notes of their patients. Dr. J. Blewett and Dr. A. M. Rackow have given me much encouragement and useful advice in the preparation of this paper.

REFERENCES

ALDRIDGE, N. H. (1956), *Amer. J. med. Sci.*, **231**, 701.
BAKER, H. L., jun., and HODGSON, J. R. (1958), *Gastroenterology*, **34**, 1137.
— — — — (1959), personal communication.
BURNETT, W., and SHIELDS, R. (1958), *Lancet*, **1**, 923.
CHRISTENSEN, W. R., and SOSMAN, M. C. (1951), *Amer. J. Roentgenol.*, **66**, 764.
COLE, W. H., and GROVE, W. S. (1952), *Ann. Surg.*, **136**, 73.
DOHRN, M., and DIEDRICH, P. (1940), *Dtsch. med. Wschr.*, **66**, 1133, quoted by HOPPE, J. O., and ARCHER, S. (1953), *Amer. J. Roentgenol.*, **69**, 635.
DUNNE, E. F., JENSEN, E. H., and HUGHES, C. R. (1951), *Cleveland Clin. Quart.*, **18**, 98.
— — — — — — (1953), *Radiology*, **60**, 210.
ESGUERRA-GÓMEZ, G. (1957), *Ibid.*, **69**, 94.
GOLDENBERG, I. S., and KUMMER, A. J. (1958), *Conn. St. med. J.*, **22**, 585.
GOOD, C. A. (1958), *Amer. J. Roentgenol.*, **79**, 892.
GORDON, I. R. S. (1953), *Quart. J. Med.*, **22**, 261.
GRAHAM, E. A. (1954), *Ann. Surg.*, **140**, 612.
GRAY, E. D. (1958), *Proc. R. Soc. Med.*, **51**, 793.
JEFFERSON, K. E. (1957), *Brit. J. clin. Pract.*, **11**, 124.
JOHNSON, P. M. (1957), *N.C. med. J.*, **18**, 533.
KERLEY, P. (1958), *A Textbook of X-ray Diagnosis*, 3rd ed., p. 474. London: H. K. Lewis & Co. Ltd.
KIRKLIN, B. R. (1933), *J. Amer. med. Ass.*, **101**, 2103.
KREMENS, V., BERGER, S. M., and COHN, E. M. (1956), *New Engl. J. Med.*, **254**, 705.
LEVENE, G., and SCHEFF, S. (1957), *Amer. J. dig. Dis.*, **2**, 533.
LEWIS, T. R., and ARCHER, S. (1949), *J. Amer. chem. Soc.*, **71**, 3753.
LODGE, T. (1955), *Recent Advances in Radiology*, 3rd ed., p. 153. London: J. & A. Churchill Ltd.

McWHIRTER, R. (1935), *Brit. J. Surg.*, **23**, 155.
MARTIN, F., and MASSIMIANO, A. G. (1952), *New Engl. J. Med.*, **246**, 488.
MAUTHE, H. (1954), *Wis. med. J.*, **53**, 473.
MITCHELL, D. J. (1956), *Brit. J. Radiol.*, **29**, 133.
MORALES, O., and SVEDBERG, J. (1949), *Acta Radiol., Stockh.*, **31**, 44.
MORGAN, R. H., and STEWART, H. B. (1952), *Radiology*, **63**, 231.
MOSCA, L. G., and SCAVINO, J. (1957), *Radiologia, B. Aires*, **8**, 15.
PARK, S. D. S. (1957), *Brit. med. J.*, **2**, 289.
REYNOLDS, L., and FULTON, H. (1958), *J. Amer. med. Ass.*, **159**, 1358.
ROGERS, J. V., jun., BONMATI, J., LEIGH, T. F., and GAY, B. B., jun. (1953), *J. med. Ass. Ga.*, **42**, 489.
ROSE, J. D. (1958), *Brit. med. J.*, **1**, 360.
RUSSO, P. E., and CAVANAGH, C. J. (1952), *Sth. med. J.*, **45**, 232.
SCHAAF, J., and WILHELM, G. (1957), *Artzl. Wschr., Berlin*, **12**, 751.
SCOTT, W. G., and SIMRIL, W. A. (1951), *J. Mo. med. Ass.*, **48**, 866.
SEEDORF, E. E., and POWELL, W. N. (1958), *J. Amer. med. Ass.*, **159**, 1361.
SHAPIRO, R. (1954), *Radiology*, **62**, 245.
SMITH, H. P., jun., and RUNGE, T. M. (1951), *Gastroenterology*, **18**, 49.
SPENCER, F. (1952), *Ibid.*, **21**, 535.
STENHOUSE, D. (1956), *Brit. J. Radiol.*, **29**, 498.
STEVENSON, J. J. (1952), *Ibid.*, **25**, 531.
SUTTON, D. (1957), *Brit. med. Bull.*, **2**, 99.
— — and TILLETT, J. V. (1954), *Brit. J. Radiol.*, **27**, 575.
WHITEHOUSE, W. M. (1955), *Surg. Gynec. Obstet.*, **100**, 211.
— — and MARTIN, O. (1953), *Radiology*, **60**, 215.
WHITTAKER, L. R., MILLIKEN, G., and VOGT, E. C. (1925), *Surg. Gynec. Obstet.*, **40**, 847.
WICKBOM, I. G., and RENTZHOG, U. (1955), *Acta Radiol., Stockh.*, **44**, 185.
WISE, R. E. (1957), *Postgrad. Med.*, **21**, 531.
ZIMMER, E. A. (1958), *Amer. J. Roentgenol.*, **79**, 869.

LEUKÆMIC INFILTRATION OF THE PROSTATE

By JOHN R. TIGHE

SENIOR REGISTRAR IN CLINICAL PATHOLOGY, ROYAL HOSPITAL, SHEFFIELD

PROSTATIC enlargement due to leukæmic infiltration is a rare cause of urinary obstruction. It should be considered in the differential diagnosis of prostatic hypertrophy because of the risk of hæmorrhage and infection in the surgical treatment of such cases. The diagnosis may be difficult and it may be mistaken for undifferentiated carcinoma of the prostate, especially in those cases due to acute monocytic leukæmia (Flaherty, Cope, and Shecket, 1940).

FIG. 681.—Leukæmic infiltration of the prostate. The right lateral lobe has been cut open to show the nodular appearance.

The first report of an authentic case of such infiltration was by Jacobi, Panoff, and Herzlich (1937). Since that time 7 further cases have been reported in the literature (McCrea, 1940; Flaherty and others, 1940; Lubin, Fetter, and Erf, 1947; Hare, Spence, and Faqua, 1949; Connor, Heinemann, and MacNish, 1950; and 2 cases by Johnson and Gundersen, 1953). Six of these cases were considered to be examples of lymphatic leukæmia and 2 of monocytic leukæmia.

A case of leukæmic infiltration of the prostate, believed to be the first report of such a condition in this country, is described below. It was not diagnosed during life, but autopsy has established the leukæmic nature of the disease.

CASE REPORT

M. H., a warehouseman, aged 65 years, was first seen as an out-patient on March 5, 1959, complaining of difficulty and pain on micturition of two weeks' duration. During this time he also had some urgency, dribbling of urine, and nocturia. He denied having hæmaturia, but it was noted on the day he attended the out-patient department that his urine was heavily blood-stained. For the previous 8–9 weeks he had been breathless on exertion and had a productive cough. His family and personal history were negative.

Examination revealed an obese man, dyspnœic at rest, but apparently not anæmic. Pulse 80, B.P. 150/90; no abnormality was detected in his cardiovascular system. High-pitched rhonchi were heard all over his chest; his liver, spleen, kidneys, and superficial lymph-nodes were not palpable. On rectal examination the prostate was firm, the lateral lobes were enlarged to approximately twice the normal size, and there was no median sulcus. The provisional diagnosis was 'benign' prostatic hypertrophy.

Arrangements were made for his admission to hospital the following week, but on March 11 he was admitted as an emergency, critically ill. He had retention of urine since the previous day and was extremely dyspnœic. On examination the patient was cyanosed. Temp. 101° F., Pulse 130, Respiration 44, B.P. 140/90. Chest expansion was poor, expiration difficult, and there were coarse bubbling crepitations throughout the lung fields. His abdomen was distended and the bladder palpable just

below the umbilicus. In spite of supportive therapy he collapsed and died a few hours later. Blood-urea shortly before death was 78 mg./100 ml.

POST-MORTEM EXAMINATION.—

Externally there was a bruise on the right forearm, and a small conjunctival hæmorrhage in the left eye. No ulceration was noted in the mouth or pharynx, but the tonsils and the follicles at the base of the tongue were moderately hypertrophied.

Internally there were petechial hæmorrhages scattered throughout the brain-stem and cerebral hemispheres, but no flattening of the convolutions or cerebellar 'coning'.

FIG. 682.—Diffuse leukæmic infiltration of the prostate. (× 48.)

The heart showed pericardial petechial hæmorrhages; the left and right ventricles showed hypertrophy and there was slight atheroma of the coronary arteries. There were petechial hæmorrhages over the pleural surfaces of both lungs, which showed anthracotic pigmentation. The lungs were firm and œdematous, particularly the right lung. The kidneys were pale and nodular and the capsule stripped moderately easily: the cut surface of the kidneys showed some thickening of the cortex, which was grey in colour, and grey streaks ran down in the intermedullary rays. The spleen (560 g.) was firm, homogeneous greyish-pink in colour, and extended a little below the costal margin. The liver (2250 g.) had a smooth capsule and showed no gross abnormality. There was cholesterolosis of the gall-bladder, which contained one 'mixed' stone. The urinary bladder was moderately dilated, but showed little or no increased trabeculation. The prostate (62 g.) was easily dissected from the bladder and measured 5 × 4 × 4 cm. It was firm, greyish-white, and showed enlargement of the lateral lobes and, to a lesser extent, the median lobe (*Fig.* 681). The cut surface was nodular, but the typical small cysts and whorls of 'benign' hyperplasia were not apparent. The stomach showed petechial hæmorrhages on the mucosal surface; there were superficial ulcers related to hypertrophied Peyer's patches in the terminal ileum. The cervical, hilar, portal, and mesenteric lymph-nodes were all enlarged up to 3 cm. diameter. They were firm, discrete, mobile, and greyish-pink. Bone-marrow from the sternum, rib, vertebræ, and mid-shaft of a femur appeared to be hyperplastic.

HISTOLOGY.—The prostate shows massive infiltration of the stroma with primitive cells (*Fig.* 682). These cells are approximately two to three times the size of adult lymphocytes; they have round or oval nuclei, some of which show infoldings, and they have an open chromatin network with occasional clumps of more darkly staining chromatin; some of the nuclei show a large solitary nucleolus, but occasionally two nucleoli are present; mitotic figures are frequent; cytoplasm is scanty and pink. These cells appear similar to those infiltrating the prostate in the case of acute monocytic leukæmia described by Flaherty and others (1940). The fibromuscular background is not prominent, but the primitive cells can be seen infiltrating the muscle-fibres (*Fig.* 683). The acini for the most part are small; they are usually lined by a single, more rarely by a double, layer of columnar or cubical epithelium and occasionally contain corpora amylacea. The epithelium does not appear to be hyperplastic.

The infiltrating cells, wherever seen, appear the same. In the liver they are most noticeable in the portal tracts, but they are also present in the sinusoids. The architecture

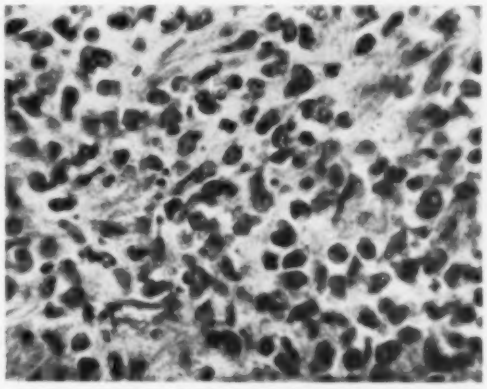


FIG. 683.—Primitive leukæmic cells infiltrating the fibromuscular stroma. (× 432.)

of the lymph-nodes is destroyed and the primitive cells extend through the capsule; mitotic figures are very frequent; a few multinucleate giant cells with eosinophilic cytoplasm, resembling megakaryocytes, are scattered throughout the nodes.

The kidneys, heart, lungs, spleen, and small intestine show similar diffuse infiltration, but without the multinucleate giant cells. The capillaries, especially in the heart and lungs, appear to be filled with primitive cells; the lungs, in addition, show œdema and hæmorrhage in many of the alveoli. The bone-marrow from the sternum, vertebra, and femur is almost completely replaced by primitive cells.

Anatomical diagnosis: Acute leukæmia, probably monocytic in type.

DISCUSSION

Two types of leukæmic infiltration of the prostate have been described (Meyer, 1941). It has been suggested that the first type, a diffuse infiltration of the gland, rarely gives symptoms, and is found more commonly in younger individuals, whereas the second type, a nodular infiltration combined with 'adenomatous' hyperplasia, occurs in older men and is more likely to give obstructive symptoms. The ages in the previous 8 cases ranged from 38 to 78 years, with an average age, including the present case, of 62 years. Most of these patients had urinary symptoms for a year or more prior to admission to hospital, and in only 3 cases was there a short history preceding the onset of acute retention; in the present case there was a history of two weeks' dysuria; the patient described by Flaherty and others (1940), a man of 38 years with acute monocytic leukæmia, had urinary symptoms for only nine days, and the patient of Hare and others (1949), a man of 46 years with chronic

lymphatic leukæmia, had dysuria for two months. However, in most of the other cases there was an acute exacerbation of symptoms one to three weeks before they developed acute retention.

Only 4 of the 9 cases have shown 'adenomatous' hyperplasia (Lubin and others, 1947; Connor and others, 1950; Johnson and Gundersen, 1953 (2 cases)); in none of these has the hyperplasia been more than moderate. The cut surface of the prostate has shown a nodular appearance in several cases, and in some it appears to have been due to foci of leukæmic infiltration rather than to glandular or fibromuscular hyperplasia.

In all the previous cases prostatectomy has been carried out, and it was usually performed quite easily without excessive bleeding. McCrea (1940) commented that the gland was enucleated more easily than the average, but Connor and others (1950) quote a personal communication from Altheide, who had a similar case to theirs of lymphatic leukæmia infiltration of the prostate. His patient bled profusely both during and after prostatectomy and required repeated transfusions. Connor and others suggest that prostatic infiltration by chronic lymphatic leukæmia should be treated by irradiation rather than by surgery, and this view is supported by Meyer (1941).

Of the 8 patients who underwent prostatectomy, 4 died within two months and 1 died three years later. Of the remaining 3 patients 1 was alive three months later, 1 eight months later, and it is unknown how long the last patient survived. In the present case death followed three weeks after the onset of urinary symptoms.

Where the patient is known to be suffering from leukæmia the interpretation of the histological appearance of the infiltrated prostate is usually not difficult, but occasionally the appearances suggest anaplastic carcinoma. This is more likely in cases of monocytic leukæmia where, histologically, there is little to distinguish the large and rather primitive cells from carcinoma cells, but even in these cases it is usually possible to detect normal acini amongst the infiltrating cells. It is important to distinguish between these conditions because irradiation is contra-indicated in monocytic leukæmia (Whitby and Britton, 1957).

Until the present time all the cases of prostatic enlargement due to leukæmic infiltration have shown either chronic lymphatic leukæmia or monocytic leukæmia. Although no hæmatological investigations were carried out during life in the present case, autopsy established the leukæmic nature of the disease. The microscopical appearances were so similar to those given in the case described by Flaherty and others (1940) that it may be assumed that this case was also one of acute monocytic leukæmia. In a search of the literature I have been unable to find a report of a case of prostatic enlargement due to infiltration in chronic myeloid leukæmia.

Watson, Sauer, and Sadugor (1949), reviewing 1073 cases of lymphoblastomas (including lymphatic leukæmia) of the genito-urinary tract, concluded that ". . . surgical intervention is not only contra-indicated but harmful in patients with lymphoblastomas of the prostate. These cases are treated best by the use of deep X-ray therapy, from which prompt relief of obstructive systems may be expected, at least temporarily." It is difficult to diagnose leukæmic infiltration pre-operatively, but the condition should be considered in those patients known to be suffering from chronic lymphatic leukæmia.

The treatment of infiltration in monocytic leukæmia is more difficult. In the 2 cases previously reported death followed within two months of prostatectomy. Irradiation is contra-indicated, and as yet there are no reports of treatment with 6-mercaptopurine or corticosteroids. In view of the poor operative risk, it is questionable whether surgery is justified in these cases.

Thus, although retention of urine due to leukæmic infiltration of the prostate is not common, it should be considered in the differential diagnosis of prostatic enlargement, especially in those cases known to be suffering from leukæmia.

SUMMARY

A case, believed to be the first reported in this country, of leukæmic infiltration of the prostate with urinary obstruction is described. Although the disease was not diagnosed during life, autopsy established the leukæmic nature of the prostatic infiltration.

The literature is reviewed and the previous reports are discussed. The possibility of leukæmic infiltration giving rise to prostatic enlargement should be considered in patients suffering from leukæmia who develop symptoms of urinary obstruction.

I wish to thank Mr. J. C. Anderson for permission to publish this case, and Dr. J. L. Edwards for much helpful advice in the preparation of this paper.

REFERENCES

CONNOR, J. J., HEINEMANN, S., and MACNISH, J. M. (1950), *Urol. cutan. Rev.*, **54**, 276.
FLAHERTY, S. A., COPE, H. E., and SHECKET, H. A. (1940), *J. Urol.*, **44**, 488.
HARE, D. M., SPENCE, H. M., and FUQUA, F. (1949), *Ibid.*, **62**, 845.
JACOBI, M., PANOFF, C. E., and HERZLICH, J. (1937), *Ibid.*, **38**, 494.
JOHNSON, M. A., and GUNDERSEN, A. H. (1953), *Ibid.*, **69**, 681.
LUBIN, E. N., FETTER, J. R., and ERF, L. A. (1947), *Ibid.*, **58**, 272.
MCCREA, L. E. (1940), *Urol. cutan. Rev.*, **44**, 694.
MEYER, L. M. (1941), *Ibid.*, **45**, 693.
WATSON, E. M., SAUER, H. R., and SADUGOR, M. G. (1949), *J. Urol.*, **61**, 626.
WHITBY, L. E. H., and BRITTON, C. J. C. (1957), *Disorders of the Blood*, 8th ed., 546. London: Churchill.

COMMON BILE-DUCT SUTURE WITHOUT INTRADUCTAL DRAINAGE FOLLOWING CHOLEDOCHOTOMY

By PATRICK G. COLLINS

CONSULTANT SURGEON, JERVIS STREET HOSPITAL, DUBLIN; FORMERLY SENIOR SURGICAL REGISTRAR, ROYAL INFIRMARY, SHEFFIELD

CHARLES R. M. REDWOOD

CONSULTANT SURGEON, ROYAL INFIRMARY, DONCASTER; FORMERLY SENIOR SURGICAL REGISTRAR, ROYAL INFIRMARY, SHEFFIELD

AND GEOFFREY WYNNE-JONES

LATE SURGICAL REGISTRAR, ROYAL INFIRMARY, SHEFFIELD

"In technical matters as in broader aspects of surgery, we should make a fetish neither of change nor of tradition, but rather attempt to be guided by logic and by critical analysis of collected experience."—*C. Rollins Hanlon*, 1958.

IT is now more than three-quarters of a century since Marcy (1882) performed the first recorded choledochotomy, and seventy years since Knowsley Thornton (1891) performed the first recorded successful operation for the removal of gall-stones from the common bile-duct. Since that time it has been accepted practice to place a drainage tube in the common bile-duct following choledochotomy. The main reasons for draining the common bile-duct by placing a catheter or a T-tube within the duct following choledochotomy are as follows:—

1. To avoid bile collecting in the peritoneal cavity.
2. To prevent stasis of bile in the biliary tree.
3. This drainage in turn may help to prevent ascending infection by decompressing the liver.
4. Post-operative cholangiography may be practised.

We believe, however, that routine intraductal drainage of the common bile-duct following choledochotomy is unnecessary and may even increase the hazard of the operation to the patient. Furthermore, we also believe that if the subhepatic space is adequately drained following primary suture of the common bile-duct, the risk of bile peritonitis is negligible.

Primary closure of the common duct following choledochotomy is not a new idea. Halstead (1897) favoured this procedure. Richter and Bushbinder (1919) advocated primary suture rather than intraductal drainage of the common bile-duct. William Mayo (1923) stated that in bile-duct exploration for quiescent or latent stones, intraductal drainage was unnecessary. Kirschner (1933) stated that drainage of the common bile-duct was an obsolete and unphysiological procedure carried down through the years and from which modern biliary surgery should finally be freed. Mirrizzi (1942) reported 31 cases successfully treated by suture of the common duct without intraductal drainage, which comprised three-quarters of the operations he had performed for choledocholithiasis in a four-year period. Edwards and Herrington (1953) and Herrington, Dawson, Edwards, and Edwards (1957) favour suture of the common duct rather than intraductal drainage, and their published figures support this view.

Millar (1956) and Ogilvie (1957) both state categorically, however, that if the common bile-duct is opened it must be drained. Glenn (1958) also favours catheter or T-tube drainage of the common bile-duct and states that meticulous bile-tight closure of the incision in the common duct about the catheter or T-tube minimizes the hazard of bile leakage into the periductal area. It seems to us that such tight suturing around a rubber tube, so as to try to prevent seepage of the non-viscous bile into the periductal region, may result in damage to the duct when the intraductal drainage tube is pulled out post-operatively.

Clearly there is still much controversy on the question of whether or not to drain the common bile-duct by intraductal drain after choledochotomy. We believe that in recent years more surgeons are closing the common duct without intraductal drainage. It is the primary object of this paper to encourage this trend.

THE INVESTIGATION

The Royal Infirmary contains three surgical units. It has been the practice in one of them (Unit A) since 1935 to close the common bile-duct almost routinely, without intraductal drainage after choledochotomy. In the other units (Units B and C) it was the invariable practice until 1953 to drain the duct; but since then the common bile-duct has been closed without intraductal drainage following choledochotomy in an increasing number of cases on these units.

We have studied cases of common bile-duct exploration from Unit A for a period of 22 years (January, 1936, to December, 1957). Cases from the other two units (B and C) are used for an 11-year period (January, 1947, to December, 1957). We have also collected a series of cases over an 11-year period (January, 1947 to December, 1957) from a hospital (Group D) of somewhat similar size where the usual practice is to drain the common bile-duct by intraductal drain following choledochotomy.

Comparability of the Different Groups.—The surgical teams on Units A and B and C were similar: each consisted of a consultant, senior registrar, and registrar, and on each unit each member of the team operated on approximately the same proportion of cases. In Group D the surgeons consisted of four consultants, one senior registrar, and one registrar.

The following items were studied and compared since they would be the most likely to bear a direct relationship to the morbidity and mortality: the age of the patient, the presence of jaundice at the time of or prior to operation, and the presence of gall-stones in the common bile-duct. The least reliable of the records related to the presence of jaundice.

Such terms as 'slight jaundice' and 'icteric tinge' made accurate assessment of this feature difficult, and this may account for the wide recorded variation in this factor (*Table II*).

The frequency of common bile-duct exploration is comparable in each series, if expressed as a percentage of the cholecystectomies performed on each Unit during the same period. In the two series from the same hospital, A and (B and C), the patients were operated on in the same theatres and the majority were treated in the same wards by the same nursing staffs.

Table I

	Hospital I				Hospital II
	Unit A		*Units B and C*		*Group D*
	Jan.–Dec. 1936–46	Jan.–Dec. 1947–57	Jan.–Dec. 1947–57		Jan.–Dec. 1947–57
Cholecystectomies					
Number	238	467	392		759
Average age (yr.)	50·7	57·6	53·2		57·5
Percentage in which common bile-duct explored	26	18·2	24·7		21·4
Post-operative hospital stay (days)	13·9	12·9	13·5		15
Mortality percentage	3	1	3		1
Common Bile-duct Explorations					
a. With cholecystectomy (number)	62	85	97		163
b. After previous cholecystectomy (number)	14	20	7		28
Total	76	105	104		191
Common Bile-duct drained after Choledochotomy					
Number (and percentage)	6 (8)	11 (10·5)	70 (67·3)		150 (78·5)
Average age (yr.)	54·3	63	57·2		58·6
Percentage in which stones present	100	82	56		61·6
Post-operative hospital stay (days)	24·8	20·8	20·6		22
Mortality (and percentage)	1	1	10 (14·2)		9 (6)
Common Bile-duct closed after Choledochotomy					
Number (and percentage)	70 (92)	94 (89·5)	34 (32·7)		
Average age (yr.)	51·8	56·5	56		
Percentage in which stones present	60	61·3	50		
Post-operative hospital stay (days)	17·9	15	18·5		
Mortality (and percentage)	2 (2·8)	2 (2·1)	0		

In Units B and C there were 104 explorations of the common duct in the years 1947–57 inclusive; 97 (24·7 per cent) of these were made in the course of 392 cholecystectomies and 7 followed previous cholecystectomy. In 70 (67·3 per cent) out of the 104 common-duct explorations, intraductal drainage was employed.

In Group D there were 191 explorations of the common duct in the years 1947–57 inclusive; 163 (21·4 per cent) of these were made in the course of 759 cholecystectomies and 28 followed previous cholecystectomy. In 150 out of the 191 explorations the bile-duct was drained intraductally either by T-tube (54 cases) or by catheter (96 cases). The remaining 41 cases have been excluded from the series because of inadequate information from the records about the technique of drainage adopted.

Table II

	Hospital I			Hospital II
	Unit A		*Units B and C*	*Group D*
	1936–46	1947–57	1947–57	1947–57
Number of common bile-duct explorations	76	105	104	150
Mean age (yr.)	53·3	57·1	63·6	58·6
Percentage of cholecystectomies in which common bile-duct explored	26	18·2	24·7	21·4
Percentage jaundiced at time of operation	70	57	60	42·4
Percentage of common bile-duct explorations in which gall-stones present	63·1	54·9	54	61·6

In Unit A there were 181 explorations of the common bile-duct in the years 1936–57 inclusive; 147 (20·8 per cent) of these were made in the course of 705 cholecystectomies and 34 followed previous cholecystectomy. In 164 (90·6 per cent) out of 181 common-duct explorations, the duct was closed without intraductal drainage. The cases in this Unit are divided into two periods: during the first of these sulphonamides were available, but not antibiotics. The mortality in these two periods is similar, but the number of days the patient spent in hospital after operation is several days longer in the first 11-year period (*Table I*). The second period is used for

POST-OPERATIVE COURSE

All cases where the operation notes were adequate to classify the type of operation performed have been included in the series. Cases of neoplastic disease of the biliary tract are excluded. One case which

spent 93 days in hospital post-operatively owing to chronic nephritis is included in the series from Unit A. Another patient in Group D, whose stay in hospital post-operatively was 78 days, and several 'long-stay' cases in the other Units due to diabetes mellitus, are included in each series.

The incidence of wound infection, subphrenic abscess, abscess elsewhere in the abdomen, wound dehiscence, and leakage of bile from the wound following removal of drain, catheter, or T-tube seemed higher to us in those cases where the common bile-duct was drained than where the common duct was sutured. Bile collected in the subhepatic space in only 2 cases from a total of 198 where the common bile-duct was sutured without intraductal drainage. In the first case in which bile collected (Unit A) no abdominal drain of any kind was used, and the abdomen was re-opened 48 hours post-operatively and drains inserted. This patient was finally discharged from hospital 28 days after the abdomen was re-opened. In the second case (Units B and C) only one small subhepatic drain was used without lateral holes following suture of the common bile-duct. This tube did not drain the bile adequately as it became blocked with an omental plug. The abdomen was re-opened on the eighth post-operative day and 800 c.c. of bile were evacuated; following this procedure the patient recovered and was discharged on the twenty-sixth day after the second operation. In one case (Group D) severe hæmorrhage from a T-tube occurred several days post-operatively, necessitating massive blood transfusions. It was obvious, however, that as a measure of morbidity many of these complications depend on very unreliable assessments of degree and are therefore fallible: we have chosen therefore to use only one figure as a true measure of morbidity, that is, the time the patient spent in hospital post-operatively. Temperature and pulse charts were studied, but in one period they were recorded 4-hourly and in another twice daily. The number of days with elevation of pulse or temperature showed little direct relationship in fact to the length of stay in hospital post-operatively, or to the noted complications. In order to serve as a standard, we have also presented the average time in days which the straightforward cholecystectomies on each unit, or group, spent in hospital post-operatively (*Table I*). To avoid having to study the records of 1856 cholecystectomies to elicit the operative mortality and the length of stay in hospital post-operatively, the following method was adopted: 200 cholecystectomies were studied from Unit A (100 from each 11-year period), and 100 cholecystectomies from Units B and C and Group D respectively, taking the first 10 consecutive cholecystectomies performed in each year over a 10-year period.

It was found that where the common bile-duct was sutured without intraductal drainage, the patient's stay in hospital post-operatively was shorter than if intraductal drainage was used (*Table I*). This finding is in agreement with the findings of Edwards and Herrington (1953) and Herrington and others (1957).

MORTALITY

This is a difficult problem to assess. The figures (*Tables I* and *III*) show clearly that the mortality is higher in those cases in which intraductal drainage was instituted; but it can be argued that the common bile-duct was probably drained in those cases which were critically ill with long-standing obstructive jaundice, or whose ducts were infected or contained biliary sand and sludge. This argument indeed may hold for cases from Units B and C. In Unit A, however, the great majority of the common bile-ducts explored were sutured primarily—164 (90·6 per cent)

Table III

	Number	Deaths
Ducts sutured		
Unit A (1936–46)	70	2
Unit A (1947–57)	94	2
Units B and C	34	0
Total number of ducts sutured (Units A and B and C)	198	4 (2 per cent)
Ducts drained		
Unit A (1936–46)	6	1
Unit A (1947–57)	11	1
Units B and C	70	10
Group D	150	9
Total number of ducts where intraductal drainage employed (Units A and B and C, and Group D)	237	21 (8·8 per cent)

of the total 181 common bile-ducts explored in a 22-year period. The overall mortality for the series of 164 common ducts sutured without intraductal drainage was less than 3 per cent. The 17 ducts that were drained in Unit A were drained for various reasons, some unknown. One common duct drained (Unit A, 1936–46) contained pus and three others contained sludge and biliary mud. Others were drained probably by new registrars not yet initiated in the technique of closing the common bile-duct without intraductal drainage, as no other reason could be deduced from the records.

Suffice it to say that in Unit A, which must have had its share of critically ill patients with obstructive jaundice due to stone in the common bile-duct, 3 of the 4 deaths from the 164 cases where primary suture of the common bile-duct was performed after choledochotomy were due to causes remote from the biliary tree (*Table IV*). In Units B and C, in the 34 cases where the common bile-duct was sutured without intraductal drainage, there was no fatality.

DISCUSSION

Those surgeons who drain the common bile-duct by T-tube or catheter following choledochotomy do so primarily to try to prevent post-operative biliary peritonitis. Suture of the common duct without intraductal drainage seems to us to be a safe and a more physiological procedure, provided that the papilla of Vater is patent, that the stones are removed from the duct and adequate drainage of the subhepatic space is assured in the post-operative period. To ensure adequate drainage of the subhepatic space at least two drainage tubes should be used to avoid the danger of one becoming blocked by blood-clot or sealed by an omental plug.

Primary suture of the common duct also avoids other disadvantages of T-tube or catheter drainage of the duct.

DISADVANTAGES OF T-TUBE OR CATHETER DRAINAGE OF THE COMMON BILE-DUCT

1. Post-operative nursing is more exacting for the patient and nursing staff when intraductal drainage is used.

2. The entero-hepatic circulation of bile-salts ceases for a week or more until the T-tube or catheter is clamped off or removed. It is generally agreed that to remove or clamp an intraductal drain before a week has elapsed runs the danger of biliary peritonitis. The absence of bile in the alimentary tract post-operatively may result in slow wound healing, anorexia, and constipation (Rundle and others, 1955). It may be thought that the passage of bile through and around the horizontal limb of a T-tube would allow appreciable quantities of bile to escape into the intestine. Rundle, Cass, Robson, and Middleton (1955) proved conclusively that this is not the case. They found that the average drainage from a short-arm T-tube is not less than that from placing a cuffed catheter in the common bile-duct following choledochotomy. This result is not surprising, as the pressure of bile in the common bile-duct does not rise high enough to overcome the normal tone of the sphincter of Oddi while a short-arm T-tube or catheter is draining the duct.

3. The irritant foreign-body reaction of a tube in the common bile-duct and the low-grade infection constantly associated with its presence may in some cases tend to increase bile drainage and occasionally lead to severe electrolyte loss, and to a persistent biliary fistula when the intraductal tube is removed (Rundle and others, 1955).

One may draw an analogy between a urethral catheter in the urinary bladder and a tube in the common bile-duct. It is difficult if not impossible to keep a bladder free from infection until an indwelling urethral catheter is removed. Likewise, it is probably useless trying to sterilize the biliary tree with systemic antibiotics until an indwelling T-tube or catheter is removed.

Table IV.—Analysis of Deaths

Unit	Number of Deaths	Sex	Age	Type of Drainage	Cause of Death	Time of Death Post-operatively	Post-mortem Examination
A, duct sutured	4	M.	69	Subhepatic	Coronary thrombosis	30 min.	Yes
		F.	64	Subhepatic	Pulmonary embolus	5th day	Yes
		M.	49	Subhepatic	Subacute bacterial endocarditis	12th day	Yes
		F.	60	Subhepatic	Shocked and cyanosed prior to death. Cause not known	36 hr.	No record
A, duct drained	2	F.	52	T-tube	Acute pancreatitis, subphrenic abscess	22nd day	Yes
		M.	60	Catheter	Inadequate information as to cause of death	—	No record
B and C, duct drained No deaths in this group where duct was sutured	10	M.	63	T-tube	Small-gut obstruction, bronchopneumonia	4th day	Yes
		F.	48	T-tube	Bronchopneumonia, cerebral softening, prolonged post-operative hypotension	27th day	Yes
		M.	68	T-tube	Cholangitis, multiple liver abscess	2nd day	Yes
		F.	78	T-tube	Bronchopneumonia	9th day	None
		F.	77	T-tube	Congestive heart failure	45 min.	Yes
		F.	56	Long-arm T-tube	Acute pancreatitis, tube removed on tenth day	19th day	Yes
		F.	49	Long-arm T-tube	Hæmorrhagic pancreatitis. (Disk amputation of ampulla—stone in diverticulum of common bile-duct mistaken for neoplasm.)	6th day	Yes
		M.	68	T-tube	Hæmorrhage from œsophageal varices, cirrhosis liver		Yes
		F.	60	T-tube	Acute pancreatitis—re-explored 18th day post-operatively for retained stone in common bile-duct	9th day after second operation	Yes
		F.	60	T-tube	Cholangitis, retained stone in common bile-duct	9th day	Yes
Group D	9	F.	63	T-tube	Cerebral thrombosis		Yes
		F.	76	T-tube	Cerebral thrombosis		Yes
		M.	73	Catheter	Bronchopneumonia		None
		M.	74	Catheter	Pulmonary embolus		Yes
		M.	79	Catheter	Biliary peritonitis, bronchopneumonia		Yes
		F.	47	T-tube	Suppurative cholangitis, acute pancreatitis		Yes
		M.	70	Catheter	Bronchopneumonia		None
		F.	57	Catheter	Hepatorenal failure, cirrhosis liver		None
		F.	81	T-tube	Bronchopneumonia		None

4. A T-tube or catheter may break off within the duct or may be accidentally pulled out before sufficient time has elapsed for the tube track to be sealed off from the general peritoneal cavity.

5. Occasionally a secondary hæmorrhage may arise from the common bile-duct due to intraductal drainage.

6. Theoretically the common bile-duct may be damaged when a T-tube is removed. Hence notching the T-tube or the use of split T-tubes is often advocated. Usually, however, common-duct strictures occur following surgical mishaps at the time of operation.

7. Long-arm T-tubes (when one end of the horizontal limb passes through the papilla of Vater) are not without their dangers. Two cases in Units B and C died from acute pancreatitis following the use of this type of intraductal drain. Admittedly, there had been operative interference with the ampulla in each case (*Table IV*). Thompson, Howard, and Vowles (1957) collected from the literature a series of 75 cases of acute pancreatitis following operations on the biliary tract. Fifty-eight (77 per cent) of these patients died. The one common factor in 62 of the 66 cases in which the operative

procedure was described was operative manipulation within the common bile-duct. In 17 of the 66 patients acute pancreatitis followed the use of a long-arm T-tube, and of these 17 patients 16 died.

TECHNIQUE ADOPTED IN EXPLORATION AND SUTURE OF THE COMMON BILE-DUCT

1. The common bile-duct is opened if possible by cutting down on a stone rather than using stay sutures placed in the duct wall prior to opening the duct.

2. If the cystic duct is large the common duct is sometimes opened by incising the cystic duct and

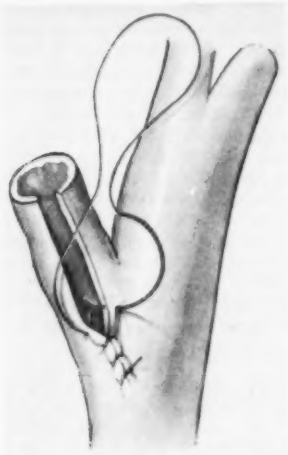


FIG. 684.—Exploration of the common bile-duct via the cystic duct.

disadvantage of this method of approach to the common duct is that there is often a flange of duct at the tissue junction of the inner margin of the cystic duct and the right border of the common bile-duct which prevents easy access with a scoop and irrigating catheter into the common hepatic duct.

3. We are content if a No. 4 or No. 5 (English gauge, 3–3·5 mm. in diameter) gum-elastic bougie traverses the papilla of Vater into the duodenum. No attempt is made to dilate the papilla up to 7 mm. with metal sounds or Bakes-type olivary dilators, as is often advocated. We think that overdilating the papilla in fact results in diminished drainage of bile through it owing to œdema, in the immediate post-operative period, and may lead to fibrosis and stenosis of the papilla at a later date. While the gum-elastic bougie is in the common duct with the tip lying free in the duodenum, it is remarkably easy in most cases to palpate the bougie along the whole length of the duct and often to feel the ampulla of Vater as a cuff of tissue on the bougie. By withdrawing the bougie slowly, the common-duct groove in which the common bile-duct lies on the posterior surface of the pancreas can be felt distinctly in the great majority of cases (Lytle, 1958).

4. No. 000 or 00 chromic catgut on a small atraumatic needle is used to close the common duct in one layer only. If the bile-duct walls are thick enough a submucosal continuous suture is used (*Fig.* 685). No attempt is made to suture the peritoneum over the repaired vertical incision in the common duct. If this is done, an extraperitoneal collection of bile may occur.

DRAINAGE

This is a most important aspect of the technique. Two drains are used (*Fig.* 686). The two drains are

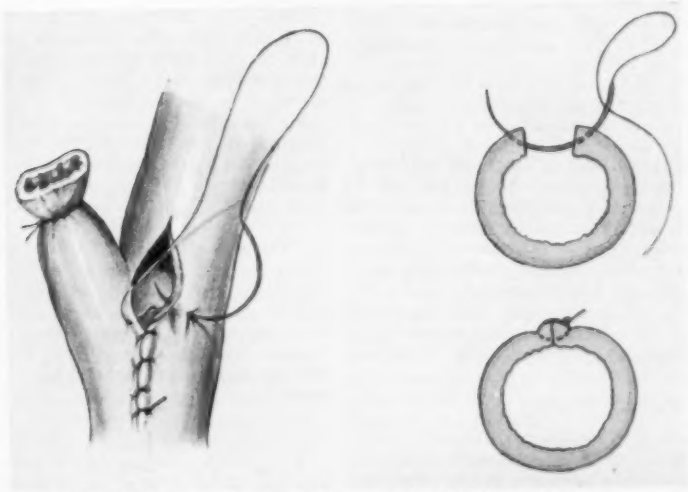


FIG. 685.—Suture of the common bile-duct using the submucosal technique.

enlarging the incision downwards and inwards into the common duct (*Fig.* 684). In Unit A this procedure was carried out on 45 occasions. The chief

brought out through the upper end of the abdominal incision, and not through a stab drain in the abdominal wall. The tube drain is removed on the fifth, and the

corrugated drain on the seventh, post-operative days respectively.

The following criteria, laid down by Mirrizzi (1942), should be fulfilled if the common duct is to be closed with safety:—

1. The papilla of Vater must be patent.
2. All intraductal calculi must be removed.
3. The pancreas must be normal to palpation.
4. Perfect suture of the common bile-duct must be effected.

It follows that in ducts which are filled with sludge and biliary mud, an intraductal drain should

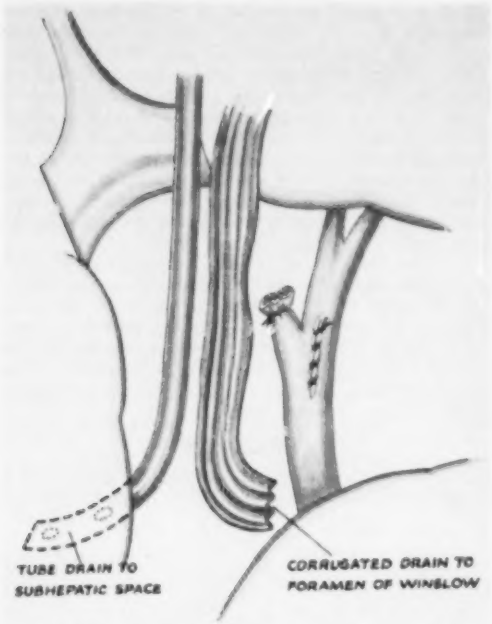


FIG. 686.—Drainage of the subhepatic space following suture of the common bile-duct.

be inserted, as it is difficult to clear the bile-duct system of debris in these cases. An infected duct, where pus is present, should also have an intraductal drain inserted. To-day, with antibiotic pre-operative therapy, pus into the common bile-duct, which was prevalent in former days, is now fortunately rare except in long-standing biliary obstruction due to bile-duct stricture. This fact may help to make primary suture of the common bile-duct, without intraductal drainage, a more widely accepted procedure.

CONCLUSION

A surgical procedure should be planned so that the patient is subjected to the least possible risk, and is returned to normal active life in the shortest possible time.

We believe that patients can be discharged from hospital several days earlier, following exploration of the common bile-duct, if the duct is sutured without intraductal drainage (provided Mirrizzi's criteria are fulfilled and adequate drainage of the subhepatic space is instituted) than if intraductal drainage is practised routinely. Primary suture of the duct is as safe as and a more physiological procedure than intraductal drainage: the latter method should be reserved for the critically ill patient who may have heavily infected bile dammed back in the liver, or whose bile-ducts are filled with biliary mud and sand: or where there is a doubt about the normality of the pancreas or the patency of the papilla of Vater.

No mention has been made of cholangiography in relation to primary suture of the common duct. We feel that operative cholangiography has many limitations owing to the false shadows often discovered due to air bubbles. It is not extensively used at the two hospitals mentioned here. It seems reasonable to conclude that the surgeon who wishes to reduce the number of retained stones can accomplish this purpose more effectively by first perfecting a sound surgical technique. It is, of course, impossible to perform post-operative cholangiography (apart from intravenous cholangiography) if primary suture of the common duct is practised. Finding a stone in the duct post-operatively, by injecting a radiopaque medium down a catheter or a T-tube, is poor solace for the surgeon, since experience has shown that a further operation will be necessary to remove it in most cases.

SUMMARY

1. Primary suture of the common bile-duct without intraductal drainage following choledochotomy has been practised in this hospital since 1935.

2. This procedure has been found to be as safe as intraductal drainage of the common duct if the cases are properly selected. Moreover, it is based on sound physiological principles.

3. On 198 occasions the common duct was sutured with an operative mortality of 2 per cent.

4. Bile was collected in the peritoneal cavity on only two occasions following primary suture of the common bile-duct. This was due on one occasion to improper drainage of the subhepatic space. The other patient had her abdomen closed without drainage of any type. Neither patient died.

5. The post-operative stay in hospital is several days shorter if primary suture of the common duct is practised.

The authors would like to extend their thanks to the consultant surgical staff of The Royal Infirmary, Sheffield, and The Royal Infirmary, Derby, for permission to publish; we appreciate especially the help and encouragement given by Mr. W. J. Lytle, Senior Surgeon, The Royal Infirmary, Sheffield. We would also like to thank Mr. A. S. Foster for the drawings.

REFERENCES

EDWARDS, L. W., and HERRINGTON, J. L., jun. (1953), *Ann. Surg.*, **137**, 189.

GLENN, F. (1958), *Surg. Clin. N. Amer.*, April, 471.

HALSTEAD, W. S. (1897), *Surgical Papers*, **2**, 472. Baltimore: Johns Hopk. Press.

HANLON, C. R. (1958), *Surg. Gynec. Obstet.*, **106**, 613.

HERRINGTON, J. L., jun., DAWSON, R. E., EDWARDS, W. H., and EDWARDS, L. W. (1957), *Ann. Surg.*, **145**, 153.
KIRSCHNER, M. (1933), *Operative Surgery* (Abdomen and Rectum), trans. RAVDIN. Philadelphia and London: J. B. Lippincott Co.
LYTLE, W. J. (1958), personal communication.
MARCY, H. O. (1882), Ochsner's *Surgical Diagnosis and Treatment*, **11**, 419 (1921). Philadelphia: Lea & Febiger.
MAYO, W. J. (1923), *Lancet*, **1**, 1299.
MILLAR, T. McW. (1956), *J. Roy. Coll. Surg., Edinb.*, **2**, 97.
MIRRIZZI, P. L. (1942), *Arch. Surg., Chicago*, **44**, 44.
OGILVIE, Sir H. (1957), *Ann. R. Coll. Surg., Engl.*, **21**, 327.
RICHTER, H. M., and BUSHBINDER, J. R. (1919), *J. Amer. med. Ass.*, **73**, 1750.
RUNDLE, F. F., CASS, M. H., ROBSON, B., and MIDDLETON, M. (1955), *Surgery*, **37**, 903.
THOMPSON, J. A., HOWARD, J. M., and VOWLES, K. D. J. (1957), *Surg. Gynec. Obstet.*, **105**, 706.
THORNTON, J. K. (1891), *Lancet*, **1**, 763.

WOUNDS OF THE HEART

BY N. A. BLUMBERG
CORONATION HOSPITAL AND UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

ALTHOUGH the first successful suture of a cardiac wound was by Rehn, of Frankfurt, in 1896, survivals are still relatively rare. In Britain the condition is not common and there are only isolated reports (Lawrie, 1955; Bell, 1957). In the United States there is an extensive literature on the subject (*Table I*). In Johannesburg penetrating chest injuries are common among the non-European population and cardiac wounds are not infrequent. The cases reported in this paper were collected from the records covering a period of 4½ years in a hospital which serves a community of approximately 146,000.

Table I.—REPORTED CASES

AUTHOR AND DATE	HOSPITAL	NO. OF CASES
Bigger (1939)	As a result of a questionnaire to 427 surgeons Personal series at the Medical College of Virginia Hospitals	124 17 141
Elkin (1941)	Grady Memorial Hospital, Atlanta	38
Elkin (1944)	Grady Memorial Hospital, Atlanta	23
Elkin and Campbell (1951)	Grady Memorial Hospital, Atlanta	18
Maynard, Cordice, and Naclerio (1952)	Harlem Hospital, N.Y. City	81
Griswold and Drye (1954)	Louisville General Hospital	108
Maynard, Avecilla, and Naclerio (1956)	Harlem Hospital	43
Blumberg (present series)	Coronation Hospital, Johannesburg	21

Cardiac wounds may be severe or so mild that they go unnoticed. Severe wounds present with either massive hæmorrhage, cardiac tamponade (compression of the heart), or a combination of both. The key to the behaviour of these wounds is the fibrous pericardium. Where there is free communication between pericardial and pleural cavities (or exterior), there will be massive hæmorrhage. Such patients are usually dead on arrival in hospital, or they die in bed, usually before any effective treatment can be started. Where there is no free communication, blood accumulates in the pericardial sac and compresses the heart. Such patients may survive for a considerable time, and even those *in extremis* can often be resuscitated and kept alive until definitive surgery can be carried out. The presence of blood under tension inside the pericardium acts as a 'stopper', and, by interfering with the venous return and ventricular filling, it also reduces the cardiac output and thereby limits the escape of blood from the wound.

THE CLINICAL PICTURE

Bigger (1939) divided cardiac wounds into four types:—

Group 1: Patients with evidence of cardiac injury, but without tamponade or massive intrapleural hæmorrhage.

Group 2: Tamponade is present but there is satisfactory response to conservative treatment, with return of arterial pressure to normal or near normal.

Group 3: Those who fail to respond, with a persistently low blood-pressure.

Group 4: Penetrating wounds of the heart with free bleeding into the pleural cavity.

Patients in Group 1 are conveniently called 'mild cases' and those in Groups 2 to 4 'severe cases'.

Severe Cases.—The patient is usually in a state of collapse, reeking of alcohol and incapable of giving a history. He may be lying in a pool of vomitus, unconscious. When responding to resuscitation, these patients usually become obstreperous, difficult to control, and incontinent. The urgency to defæcate is probably due to a combination of cerebral anoxia, pelvic congestion, and alcohol. The external wound is in most cases over the precordium, but it may be at a remote site—e.g., the root of the neck. The other features will depend on the predominance of hæmorrhage or tamponade. The features of hæmorrhage require no special mention. Bigger (1939) described a characteristic churning or slapping sound, coinciding with the heart-beat, in cases where both air and blood are present in the pericardial cavity. This is said to occur where there is free communication between pleural and pericardial cavities.

Cardiac Tamponade.—It is so often possible to rescue patients with tamponade that it is paramount

in the treatment of cardiac wounds to recognize its presenting features. These are as follows:—

Pulse: It may be paradoxical, absent, or faint.

Veins: There will be generalized venous congestion.

Blood-pressure: Low or unrecordable.

Cardiac Impulse: Markedly diminished or absent.

Heart-sounds: Faint and distant.

Cardiac Dullness: May be increased because of fluid inside the pericardium. The heart itself is small because it is inadequately filled. This sign may be confused by a concomitant hæmothorax or pneumothorax and is generally unreliable.

Beck's triad for acute cardiac compression comprises: (1) Falling blood-pressure; (2) Rising venous pressure; (3) Small quiet heart.

Of all the features, venous congestion is the most important single sign.

THE VALUE OF X RAYS

In doubtful cases, where the patient's general condition is satisfactory, further investigation by X rays or screening should be undertaken. One hundred to two hundred c.c. of fluid are sufficient to produce cardiac tamponade (Best, 1954), hence radiography is not always helpful and it may be necessary to screen the patient to demonstrate a small effusion. It is unjustifiable and unnecessary to subject a serious case to X-ray investigation. Bedside radiographs are unreliable and these cases are too ill to move to the X-ray Department, and the time wastage may prejudice the patient's chances. In these cases a clinical diagnosis has been found to be adequate. Griswold and Drye (1954) condemn technical diagnostic tests as time-consuming in all but mild cases.

THE VALUE OF ELECTROCARDIOGRAPHY

Noth (1946) carried out an exhaustive investigation into this most complex subject. There are many factors which may influence the electrocardiographic pattern—the localized lesion, pericarditis, involvement of a coronary vessel, the presence of shock, anæmia, the presence of blood or air in the pleural cavity. The E.C.G. pattern in South African Bantus is unlike that of Europeans, and interpretation of their E.C.G.s is often confusing even under more straightforward circumstances. In a high proportion of cases there are inverted T waves and S–T elevation with apparently normal hearts (Grusin, 1954).

The picture of pericarditis may closely resemble that of myocardial infarction—e.g., T-wave inversions, raised S–T segments—even in the absence of a cardiac wound. Localizing patterns found in the first 24 hours after injury may indicate a ventricular wound. A bundle-branch block may occur with right ventricular wounds. Even so, Noth agrees that operative indications are more dependent on clinical findings and screening.

CONSERVATIVE TREATMENT

This consists essentially in the administration of intravenous fluids and pericardial aspiration, repeated if necessary.

Aspiration.—Cooley, Dunn, Brockman, and De Bakey (1955) produced experimental cardiac tamponade in dogs by instilling saline into the pericardial sac. *They found that so long as the venous pressure exceeded the intrapericardial pressure, cardiac filling would occur and the circulation could be maintained.* Similar observations were made by Cooper, Stead, and Warren (1944). When the intrapericardial pressure rose to a level where it equalled or almost equalled the venous pressure, arterial pressure fell sharply and cardiac action ceased, unless the pericardial pressure was released. This is the rationale of pericardial aspiration of even small quantities of fluid, e.g., 5–10 c.c. Aspiration is done through the left 5th intercostal space, immediately adjacent to the sternal border, or through the left costo-xiphoid angle.

Intravenous Fluid Administration.—Although not all surgeons are agreed on the value of intravenous infusions in the presence of tamponade, experimental as well as clinical evidence shows that they are of value and should be employed in the early stages. Blood is the fluid of choice. Cooley and others (1955) showed experimentally in their dogs that intravenous infusions, by raising the venous pressure further, enhance cardiac filling. Experiments in dogs by Cooper and others (1944) also showed that *a rapid intravenous infusion, with subsequent increase in blood-volume, enabled the animals to withstand very much higher intrapericardial pressures than they could without such infusions.* Another requirement for cardiac filling to occur in the presence of tamponade is the ability of the pericardium to stretch. In these animals at any rate, the pericardium appeared to stretch with the increased cardiac filling which followed raising of the intravenous pressure with infusions. These authors found that their own patients benefited from infusion; in each case arterial pressure rose and patients became more rational. In the present series of cases it was also found that the patients benefited from transfusion.

Cooley and others (1955) showed experimentally that the vasoconstrictor drugs, e.g., noradrenaline, even in the presence of tamponade, raised the blood-pressure. This is predominantly due to vasoconstriction, not to a rise in cardiac output.

THE OPERATION

General anæsthesia is employed. Elkin (1944) described an extrapleural approach, but the transpleural route is popular among most authors. The approach is from the left side, even with right-sided external wounds, unless the wound is far out to the right. Maynard, Cordice, and Naclerio (1952) recommend a left thoracotomy for all cases, irrespective of the location of the external wound.

The approach is through the 4th or 5th intercostal space (*Fig.* 687). At the sternal border the costal cartilage above and below is divided with the scalpel. If necessary, the incision can be extended upwards along the left sternal border. Laterally the incision extends to the mid-axillary line. The internal mammary vessels are clamped and divided and later ligated. The pleura is opened and a Finochietto rib spreader is inserted and opened wide.

The distended pericardium is seen, purple in colour and pulsating feebly. The pericardial wound may be visible or obscured by blood-clot, when it may be located by passing down a probe from the external wound. The assistant is poised with a sucker and a myocardium across the wound itself, but care must be taken that the endocardium is not penetrated. These sutures must not be tied too tightly.

Beck (1926) has introduced a novel method of controlling the bleeding. Whilst traction is made on

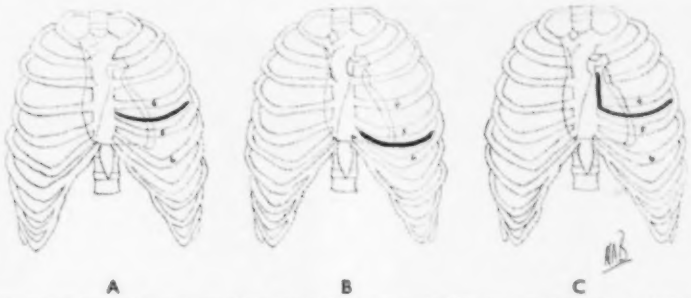


FIG. 687.—Diagram showing surface anatomy of the heart. The lines of incision are superimposed. **A**, Incision in left 4th intercostal space; **B**, Incision in 5th intercostal space; **C**, showing how additional exposure can be obtained by extending the medial end of the incision upwards, along the sternal border.

long vertical incision is made in the pericardium, taking care to avoid the phrenic nerve. A furious gush of blood ensues. As the assistant sucks away, the wound is generally displayed. The surgeon then gently but firmly places the pulp of his left index finger over the hole and arrests the flow. The finger must not be pushed into the hole because the myocardium may tear. Beck (1926) recommends that the first step, after opening the pericardium, before even looking for the wound, is to pass a stay suture through the thick-walled muscle of the apex so that the apical suture and the left index finger covers the wound, a control suture is passed on each side of the hole, parallel to it and as near the margin as the overlying finger permits. The control sutures are now

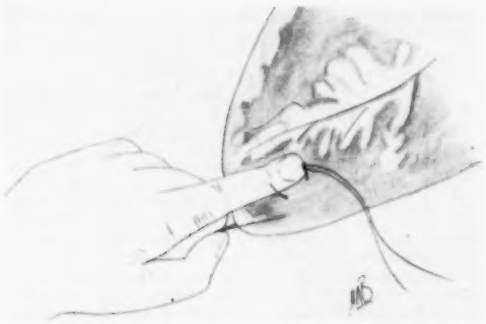


FIG. 688.—Beck's manœuvre. The apical suture is held between the thumb and middle finger, while the index finger covers the wound. (*By courtesy of Beck and the Editor, 'Archives of Surgery', Aug.*, 1926.)

FIG. 689.—By crossing the control sutures, bleeding is controlled and the wound can be carefully sutured. (*By courtesy of Beck and the Editor, 'Archives of Surgery', Aug.*, 1926.)

traction can be exerted simultaneously to cover the wound (*Fig.* 688). By this manœuvre the hand can 'ride' with the cardiac pulsation, which becomes strong once the tamponade is relieved.

With the finger in position over the hole, a fine silk suture is passed through the myocardium, but not penetrating the endocardium, at the upper end of the wound. A similar suture is passed at the lower end. The assistant gently holds these up. He must allow these sutures to 'ride' with the cardiac pulsation, otherwise they will tear out. A few interrupted fine silk sutures are now passed deep into the crossed and gently held up by the assistant (*Fig.* 689), the apical suture is dropped, and the index finger removed. The bleeding is now controlled and the wound can be sutured at leisure; the coronary vessels can be clearly visualized and deliberately avoided (*Fig.* 690). If the wound is very large several such control sutures can be placed *ad seriatim* alongside each margin of the wound and the whole crossed to control bleeding. Two or three permanent sutures are generally adequate. The bleeding is now arrested and the free blood sucked away. The control sutures are removed and the heart movements are observed

and further bleeding is watched for. To prevent rhythm disturbances, the heart should be disturbed as little as possible, but to reach inaccessible parts it may be necessary to lift the organ gently forward at the apex, either with the fingers or by the apical suture. Compression of the heart, whilst producing a dry field, should not be done unless bleeding is so

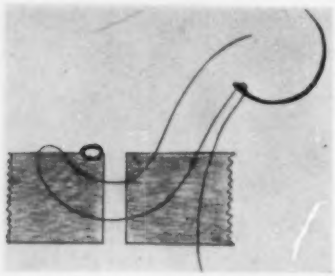


FIG. 690.—Where the wound is so close to a coronary vessel that the latter would be damaged by a conventional suture, a vertical mattress suture can be passed deep to the vessel.

severe that the perforation cannot be identified. In such cases Sauerbruch's manœuvre should be employed (*Fig.* 691). Experimentally it was shown that even the gentlest handling of the pericardium invariably resulted in adhesion formation (Beck, 1926). To avoid the undesirable sequelæ of such adhesions, viz., cardiac compression, the pericardium is left unsutured, and hæmostasis is carefully secured along its cut edges (*Figs.* 692, 693). Maynard and others (1952) reported a case where the pericardium had been partially sutured at the first operation; an effusion developed and the patient had to undergo a second operation, when a portion of the pericardium was excised. When hæmostasis has been secured, the chest is closed with underwater drainage.

Post-operative Treatment.—Griswold and Maguire (1942) recommend post-operative heparin since one of their cases developed a mural thrombus. The patient receives antibiotics for as long as is indicated in the individual case. A combination of penicillin and streptomycin or a broad-spectrum antibiotic may be used. The patient receives breathing exercises and limb exercises from the second day. The pleural drain is removed when drainage becomes minimal or ceases, the pressure in the tube becomes negative, and when post-operative radiographs show re-expansion of the lung.

The duration of bed-rest will depend on the severity of his injury, nature of other injuries, and absence of post-operative complications. Usually the patient is up after one week.

CASES WHICH UNDERWENT OPERATION

In the cases below, the time interval between the admission and commencement of operation is indicated. This interval is only a guide. It is quite likely that patients have been lying around outside for some time before they are brought into hospital; one can rarely obtain a history.

Case 1.—J. M., a male aged 28 years, was admitted on Aug. 14, 1954, with a 1-in. stab wound in the 2nd intercostal space, about 1½ in. from the left sternal border. He presented with a blood-pressure of 40/20 and cardiac tamponade, and a pericardial rub was present. Radiography of the chest showed fluid in the pericardium and E.C.G. showed changes compatible with pericarditis. The patient was given blood. Four attempts at aspiration were made and a total of 250 c.c. were withdrawn. His

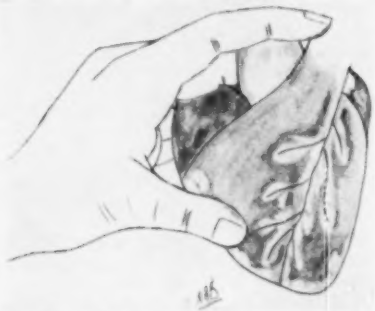


FIG. 691.—Sauerbruch's manœuvre. The left middle finger is passed through the transverse sinus of the pericardium. The 4th and 5th fingers are behind the superior vena cava and the right atrium. The index finger is in front of the aorta and pulmonary trunk. The superior vena cava, aorta, and pulmonary trunk can be compressed between these fingers, to produce a dry field. The thumb controls the heart and can be passed behind in order to lift the organ forwards, if necessary. (*By courtesy of Beck and the Editor, 'Archives of Surgery', Aug.*, 1926.)

general condition improved and the blood-pressure was maintained at 100/60 with a noradrenaline drip. After a time his condition began to deteriorate and his tamponade became severe despite the aspirations. He underwent operation 37 hr. after admission. There was a ¼-in. wound in the upper part of the right ventricle. Bleeding was controlled with the index finger, but when the sutures were tied the myocardium tore like wet blotting-paper and the patient became exsanguinated. Five pints of blood were given into the left ventricle and the hole was eventually closed, but the patient died on the table.

AUTOPSY REPORT.—There was a wound penetrating the right ventricle and extending into the interventricular septum. There was a second laceration of the right ventricle adjacent to the first wound. The interventricular branch of the left coronary artery was divided. There was a small amount of organizing clot in the pericardial sac and early fibrinous pericarditis was present. There were 20 oz. of clotted blood in the left chest cavity and the lung was collapsed. There was general pallor of organs. The cause of death was hæmorrhage.

Comment.—Massive hæmorrhage and division of coronary artery. It is not clear whether the myocardial softening was due to the age of the lesion or division of the coronary artery.

Case 2.—J. L., a male aged 23 years, was admitted on Jan. 19, 1957, with a precordial stab wound and cardiac tamponade. Blood-pressure was unrecordable. He was reeking of alcohol and incontinent. He was given 1000 c.c. of blood and operation was commenced 15 min. after admission. About half a pint of blood was evacuated from the pericardium. A small wound was found in the right ventricle. This was closed with silk. Chest closed with drainage. He developed some post-operative atelectasis of the right lower lobe and basal consolidation, with a pleural effusion. He received antibiotics for 10 days. Temperature settled on the eighth day. His lung cleared rapidly and he was discharged on Feb. 9.

Case 3.—J. D., a male aged 26 years, was admitted on March 7, 1957, with a wound in the left 3rd intercostal space, above the nipple, and two non-penetrating wounds

posteriorly. He smelled strongly of alcohol and was severely shocked, with a blood-pressure of 40/0 and extremely restless. There was a paradoxical pulse and heart-sounds were muffled. He was given 5 pints of blood. Operation was commenced 1½ hr. after admission. There was a large quantity of blood-clot inside the pericardium. A wound of the right ventricle was closed with silk. The

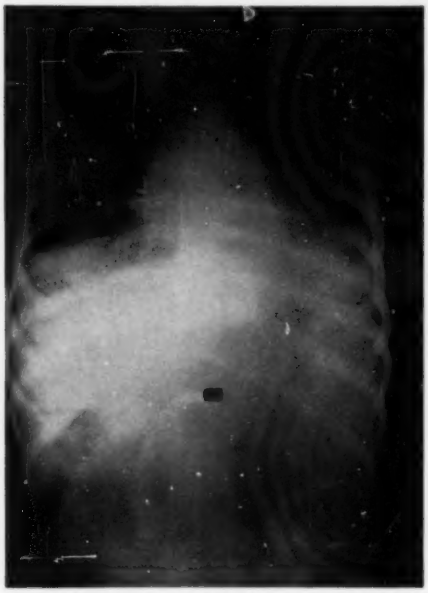


FIG. 692.—Large pericardial effusion which developed after operation. The pericardium was still bleeding when the chest was closed.

chest was closed with drainage. The patient was given antibiotics and his temperature settled on the twenty-first day. Fluid collected in the left pleural cavity. This cleared with breathing exercises. He was discharged on April 9.

Case 4.—D. M., a male aged 28 years, was admitted on March 23, 1957, in a state of severe shock and with an unrecordable blood-pressure. There was a stab wound along the right side of the sternum in the 3rd intercostal space. Operation was commenced ¾ hr. after admission. A 1-in. wound of the right ventricle was found and this was closed with silk sutures. Bleeding persisted from another wound which was not found. The patient had a cardiac arrest and received cardiac massage. An aortic transfusion was given. Despite these measures, the patient could not be resuscitated and he died on the table.

AUTOPSY REPORT.—Wound of the right ventricle, passing through into the posterior pericardium. 58 oz. of blood were found in both pleural cavities combined and both lungs were collapsed. Blood alcohol 0·05 per cent.

Comment.—Through-and-through wound with massive hæmorrhage. Bilateral pulmonary atelectasis.

Case 5.—J. S., a male aged 28 years, was admitted on July 15, 1957, in severe shock. He was unconscious and smelled strongly of alcohol. There was a ½-in. wound over the 2nd intercostal space to the left of the sternum. The area of cardiac dullness was increased to percussion. Heart-sounds were distant. A plasma transfusion was commenced and this was followed by blood, of which he received 2000 c.c. Operation commenced 1 hr. 25 min. after admission. A wound was found in the left atrium. This was closed without difficulty. *The pericardium was still bleeding when the chest was closed.* Post-operatively he developed signs of tamponade (*Fig.* 692) and on July 17 120 c.c. of blood were aspirated from the pericardium. Thereafter he received a short course of mersalyl therapy. Patient developed a left basal pneumonia which cleared uneventfully. When he was discharged on Aug. 19, the

FIG. 693.—Marked decrease in size of cardiac shadow—5 weeks after operation.

cardiac shadow was still increased in size, though smaller (*Fig.* 693).

Case 6.—B. N., a male aged 32 years, was admitted on Aug. 17, 1957 *in extremis*. He was reeking of alcohol and no history was obtainable. There was a stab wound in the left 3rd intercostal space just to the left of the sternum. There was cardiac tamponade; he was pulseless and the blood-pressure was unrecordable. Heart-sounds were faint and the neck veins and those of the limbs were markedly distended. A drip transfusion was immediately started and the patient was given 3 pints of blood. He then became restless and incontinent. Operation was commenced 45 min. after admission. The pericardium was opened and blood-clot evacuated. A small wound was found in the left atrium just above the atrioventricular ring. This was closed with several interrupted sutures of silk. He received post-operative breathing exercises and antibiotics. Temperature was normal by the fifth day. On the sixth day the drain was removed and on the twelfth day the patient was allowed up. He was discharged on Sept. 11. When seen five months later, he was well. (*Figs.* 694, 695.)

Case 7.—J. M., a male aged 23 years, was admitted on May 18, 1958, with a long laceration along the left side of the sternum, extending from the 4th rib down to the level of the umbilicus. There was a wound of the heart and division of the diaphragm, and loops of bowel were protruding through the lower end of the incision. The patient was severely shocked and bleeding actively from the cardiac wound. He was given 1 c.c. of coramine, methedrine mg. 30, and a plasma transfusion, followed by

blood. Operation was commenced 1¾ hr. after admission. The patient was intubated and given oxygen. The wound was extended proximally and a ½-in. laceration of the heart wall was displayed. This involved myocardium only and did not penetrate the endocardium. The wound was sutured, the diaphragm repaired, and a wound of the stomach was closed. The protruding bowel was then reduced and the abdominal wall repaired. The chest was drained for three days. The patient received an intensive course of antibiotics and breathing exercises. Notwithstanding, he developed a left basal consolidation, followed by an empyema. This was aspirated several times with instillation of penicillin solution into the pleural cavity at the end of the aspiration. On July 17 (two months after the first operation) a portion of the left 9th rib was resected and the empyema cavity drained. An interesting event occurred shortly after this. On Aug. 8 some lipiodol was introduced into the chest to assess the size of the cavity. During the procedure the patient collapsed and became unconscious. He came round rapidly, but was totally blind. The diagnosis was made of poppy-seed oil embolism and the patient was treated with antispasmodics and heparin and made a complete recovery after giving his medical attendants a few anxious days. He was discharged from hospital on Aug. 30.

FIG. 694.—Radiograph, taken 2 weeks after operation, showing pericardial effusion.

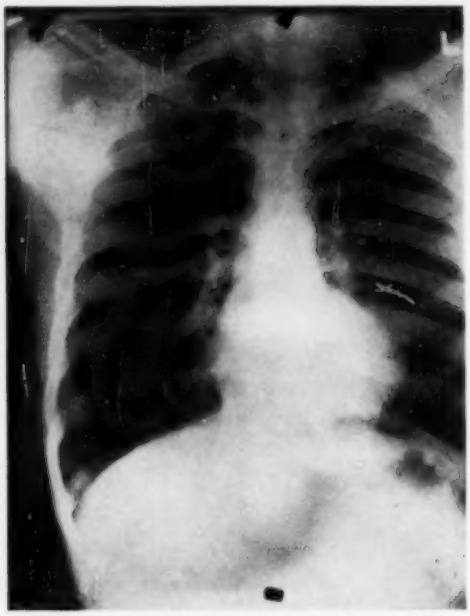


FIG. 695.—Radiograph taken after 5 months, showing normal cardiac shadow.

CASES WHICH WERE TREATED CONSERVATIVELY

Patients admitted with penetrating chest wounds are often in good condition. In other circumstances the patient may be in a state of shock, ascribable to the pneumothorax or hæmothorax, and he responds well to resuscitation and maintains the response. In some of these cases, subsequent radiography of the chest reveals fluid inside the pericardium, although there is no clinical evidence of cardiac injury. These patients would fall into Bigger's (1939) first group and the mildness of the picture and the favourable outcome with conservative treatment may be due to the absence of complete penetration of the heart wall.

Case 8.—B. M., a male aged 16 years, was admitted on May 29, 1954, with a precordial penetrating wound of the chest. His general condition was good and he was placed on antibiotics. A radiograph of the chest showed a pneumopericardium, but no fluid. Patient seemed well and, because of the need for beds, he was discharged 3 days later. On June 3 he was re-admitted with hæmoptysis and surgical emphysema over the left side of the chest and left arm. The chest was radiographed again and showed the presence of a pericardial effusion. He received further antibiotic therapy and bed-rest and the effusion rapidly cleared. Patient was discharged on June 24.

Comment.—Delayed hæmorrhage.

Case 9.—B. M., a male aged 24 years, was admitted on Aug. 22, 1954, with a stab wound in the left axilla and a left hæmothorax. He was in a state of collapse, heart-sounds were faint, pulse and blood-pressure were unrecordable. He was given 1000 c.c. of blood and his condition improved. The hæmothorax was confirmed by radiography. On the second day he suddenly collapsed and died (36¾ hr. after admission).

AUTOPSY REPORT.—The wound in the left axilla entered the pleural cavity through the third intercostal space, transfixed the upper lobe of the left lung, entered the left ventricle anteriorly, and passed out through the left ventricle posteriorly. There was also a non-penetrating thoracic wound at the back. The entry into the left ventricle was adjacent to the interventricular septum. There were 10 oz. of blood in the pericardium and 20 oz. of blood in the pleural cavity. There were infarcts throughout the right cerebral hemisphere and some

subarachnoid hæmorrhage confined to the occipital lobes of the brain.

Comment.—A combination of tamponade and hæmorrhage as well as head injury. The sudden collapse was probably due to a sudden delayed hæmorrhage.

Case 10.—J. M., a male aged 29 years, was admitted on May 19, 1955, with a penetrating stab wound in the left 3rd intercostal space, in the anterior axillary line. There was evidence of hæmothorax on the left side, but his general condition was good. A radiograph taken on the day of admission showed a pneumothorax with a large collection of fluid in the left pleural cavity. He received antibiotics. A second radiograph taken 9 days later, when some of the fluid had begun to absorb, showed an increase in the cardiac shadow. An E.C.G. showed changes compatible with pericardial effusion. The patient was screened and re-radiographed on June 27 (18 days after admission) and the condition had resolved.

FIG. 696.—Large pericardial effusion, 1 week after injury.

Case 11.—J. M., a male aged 24 years, was admitted on May 22, 1955, with a wound over the sternum. He was shocked, with a blood-pressure of 65/70, but there was no tamponade. He responded to resuscitative measures. A chest radiograph on the second day showed a pericardial effusion, which absorbed with no further treatment. He spent a few days in bed and was discharged on June 7.

Case 12.—I. M., a male aged 45 years, was admitted on Sept. 19, 1955, with multiple stab wounds of the chest. There were wounds of the left side of the chest anteriorly and posteriorly and several wounds posteriorly of the right side of the chest. His general condition was good, with a blood-pressure of 110/60. There was gross surgical emphysema on the left side and radiography showed collapse of the left lung with deviation of the mediastinum towards the right side. A needle was inserted into the chest to relieve the pneumothorax. Subsequent radiographs taken to follow the progress of the pleural lesion showed a pericardial effusion. This was confirmed on screening on Sept. 30. E.C.G. was normal. Patient improved with no further treatment and was discharged on Oct. 30.

Case 13.—J. M., a male aged 24 years, was admitted on Oct. 28, 1955, in a state of shock. There was a wound just above and to the left of the left nipple. Patient's condition improved soon after he had been put into bed and his blood-pressure rose to 120/95, at which level it was maintained. A radiograph of his chest, two days after admission, showed fluid in the left pleural cavity and an increase in heart size. E.C.G. showed changes compatible with pericardial effusion. A repeat radiograph 4 days later showed a decrease in the size of the cardiac shadow, but there was still slight enlargement 16 days later.

Case 14.—J. M., a male aged 28 years, was admitted on April 21, 1956, with two wounds over the right scapular area and one over the left scapular area, 2 in. from the midline, at the level of D.4. He was reeking of alcohol. His general condition was good. A chest radiograph taken on the third day showed an increase in the cardiac size. E.C.G. showed nothing of note. Patient was discharged on May 1.

FIG. 697.—Though the cardiac shadow is still increased, it is markedly smaller.

Case 15.—J. M., a male aged 15 years, was admitted on May 4, 1957, with a wound over the right 3rd and 4th intercostal spaces, 1½ in. from the midline. There was decreased air entry with dullness to percussion over the right side of the chest. The patient was shocked, with a blood-pressure of 90/60. There was also a laceration in the right shoulder region. He was given a blood transfusion on admission. A chest radiograph confirmed the presence of a large hæmothorax on the right side, with some mediastinal displacement. He became dyspnœic and several thoracenteses were done with withdrawal of large quantities of blood. A radiograph taken on May 11 (1 week after admission) showed enlargement of the cardiac shadow (*Fig.* 696). E.C.G. showed a pattern compatible with pericardial effusion, and this returned to a normal pattern with resolution of the pericardial effusion. The pericardium was not aspirated. Patient received antibiotics. He was eventually discharged from hospital on July 18, clinically fit, with the effusion much smaller, but the cardiac shadow still increased (*Fig.* 697).

Case 16.—J. M., a male aged 30 years, was admitted on Sept. 1, 1957, with a wound over the left anterior triangle of the neck, surrounding which was marked surgical emphysema. Patient's general condition was good. A radiograph of the chest showed a small pneumothorax with enlargement of the cardiac shadow. He was given antibiotics and discharged on Sept. 21.

Case 17.—T. Z., a male aged 19 years, was admitted on Dec. 25, 1957, with a penetrating chest wound. He was reeking of alcohol and his general condition was good. A radiograph of the chest revealed a large pericardial effusion. E.C.G. showed a pattern which was compatible with a pericardial effusion. Patient was discharged clinically well on Jan. 15, 1958, but the cardiac shadow was still increased.

PATIENTS DEAD ON ADMISSION TO THE WARD OR SHORTLY AFTERWARDS

Case 18.—J. M., a male aged 21 years, was admitted on Jan. 18, 1954, with a wound over the 2nd intercostal space to the left side of the sternum and two lacerations about the scalp. The patient was dead on arrival in the ward.

AUTOPSY REPORT.—There was a wound of the right ventricle and 8 oz. of free blood in the pericardial cavity. There were 42 oz. of blood in the left chest cavity and the lung was collapsed. Blood-alcohol level 0·13 per cent.

Case 19.—Z. D., a male aged 26 years, was admitted on May 8, 1955 *in extremis*. There was a wound on the left side of the chest in the 3rd intercostal space, in the midclavicular line. The patient died before any treatment could be administered.

AUTOPSY REPORT.—There was a wound of the left ventricle and 6 oz. of blood inside the pericardium. There were 16 oz. of blood in the pleural cavity.

Case 20.—A. L., a male, was admitted on July 2, 1955. He had a wound in the left 4th intercostal space 1½ in. from the midline, and blood was leaking from this. He was given blood under pressure but died after 20 min.

AUTOPSY REPORT.—There was a wound of the right ventricle, passing through the septum into the left ventricle. There were 4 oz. of blood in the pericardial sac and 40 oz. of blood in the left pleural cavity. No alcohol in blood.

Case 21.—M. T., a male aged 26 years, was admitted on Jan. 25, 1957, with a wound over the left 5th intercostal space and multiple other wounds. There was a wound on the right side of the neck. There were a number of head lacerations. The patient was *in extremis* and died 2 min. after arrival in the ward.

AUTOPSY REPORT.—The main chest wound entered the left ventricle near the apex of the heart and passed out through the posterior surface of the left ventricle. There were 4 oz. of blood in the pericardium and 40 oz. of blood in the left pleural cavity. The wound on the right side of the neck passed down into the apex of the right lung, but appeared to be of no consequence. One head laceration passed into the superficial layers of the right frontal lobe of the brain. Blood-alcohol level 0·09 per cent.

Comment on These Cases.—The striking feature in these cases is the massive hæmorrhage. However, there are additional factors which influence the picture. There was sufficient blood in the pericardial sac in each case to produce tamponade, particularly in *Cases* 18 and 19, where there were considerable pericardial collections; 100–200 c.c. of fluid are all that are required to produce tamponade (Best, 1954). *The patient can cope with cardiac tamponade, provided he has an adequate blood-volume.* This could explain why *Case* 19 succumbed to a hæmorrhage which, although large, would in itself have been unlikely to kill the patient. Other factors may be the influence of alcohol, arrhythmias, pulmonary atelectasis, etc. Cooley and others (1955) showed experimentally that alcohol decreased the resistance of dogs to tamponade and also interfered with resuscitative effects of noradrenaline. The role of additional factors is a subject which requires more investigation.

DISCUSSION

Most authors feel that serious cases should be treated by operation. Maynard and others (1952) and Maynard, Avecilla, and Naclerio (1956) favour operation. They decry the efficacy of aspiration because of the invariable interference from clotted blood in the pericardial sac. Griswold and Drye (1954) favour surgery in serious cases. There are, however, some weighty opinions in favour of conservative treatment. Elkin and Campbell (1951) and Cooley and others (1955) recommended a trial of conservative treatment in all cases. Operation is only undertaken if conservative therapy has failed.

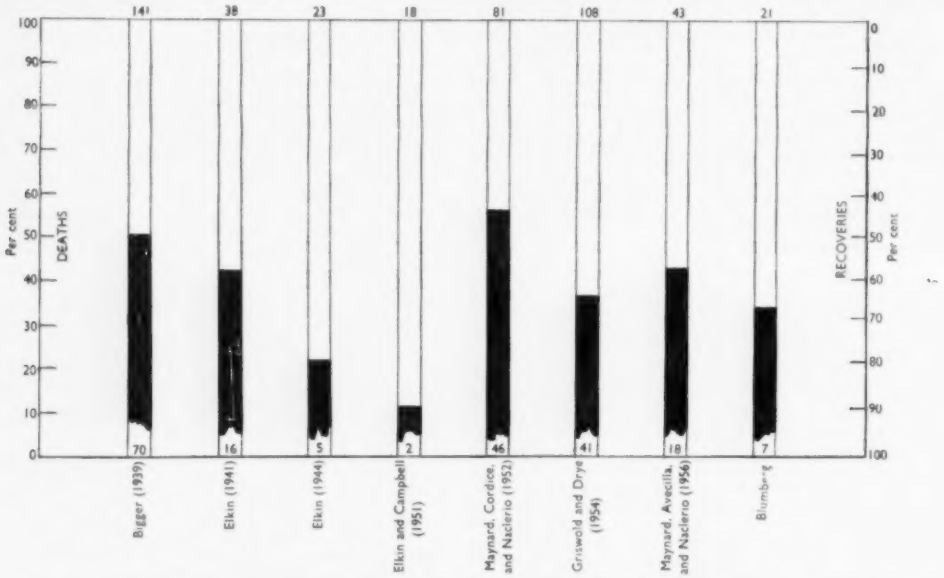


FIG. 698.—This illustrates the mortality for cardiac wounds of all types, irrespective of type of treatment. The figures on the top line indicate total number of cases; the bottom figures indicate number of cases who died.

Mortality.—This remains high (*Fig.* 698). Elkin and Campbell (1951) treated 17 cases conservatively (*Table II*), with 1 death, and 1 case subjected to operation died. Cooley and others (1955) found, in an analysis of 57 cases, that the mortality-rate was higher in cases subjected to operation. Maynard and others (1952) had 35 recoveries in 61 patients who

underwent surgery. Griswold and Drye (1954) reported an operative mortality of less than 25 per cent.

Fig. 699 shows that the survival rate with conservative treatment ranges between 90 and 100 per cent, whereas the highest survival figure for operation was 78 per cent (Elkin, 1944). These figures are open to criticism because they represent the results only of definitive conservative treatment. *All* patients who are admitted to hospital alive and who die without undergoing operation must be considered as conservative treatment failures and should be included in the analyses. This includes patients who die shortly after admission, e.g., *Cases* 18–21. With their inclusion the rosy complexion of results with conservative treatment takes on a different hue. In the series of Maynard and others (1952) the mortality-rate was 100 per cent for cases not subjected to operation. In the series of Griswold and Drye (1954) the mortality was 80·8 per cent. In the present series it was 33·3 per cent. Apart from Elkin and Campbell, the survival rate with surgery is higher (*Fig.* 700).

Table II.—Analysis of Cases

Author	Cases without Operation	By Operation	Total
Bigger (1939)	—	124 collected 17 personal	124 17 141
Elkin (1941)	—	38	38
Elkin (1944)	—	23	23
Elkin and Campbell (1951)	17	1	18
Maynard, Cordice, and Naclerio (1952)	20	61	81
Griswold and Drye (1954)	26	82	108
Maynard, Avecilla, and Naclerio (1956)	11	32	43
Blumberg (present series)	14	7	21

Of 18 cases treated conservatively by Elkin and Campbell (1951) 12 were not severe. In the remaining 6 there were 2 deaths. One died during conservative treatment, 90 min. after admission. The second patient was subjected to operation after failure of conservative treatment (admission–operation interval not stated). The remaining 4 cases showed a satisfactory response to conservative treatment; they may have had mild injuries. The analysis by Cooley and others (1955) is open to criticism. If the aspirated blood did not coagulate, they concluded that the cardiac wound was a penetrating one. This method of diagnosis leaves much room for doubt, and it is likely that many of their cases did not have penetrating wounds, i.e., they were mild injuries.

Morbidity.—The type of person with whom one is dealing is usually unco-operative and follow-up of these cases is unsatisfactory. All the patients in the present series were seen one month after discharge

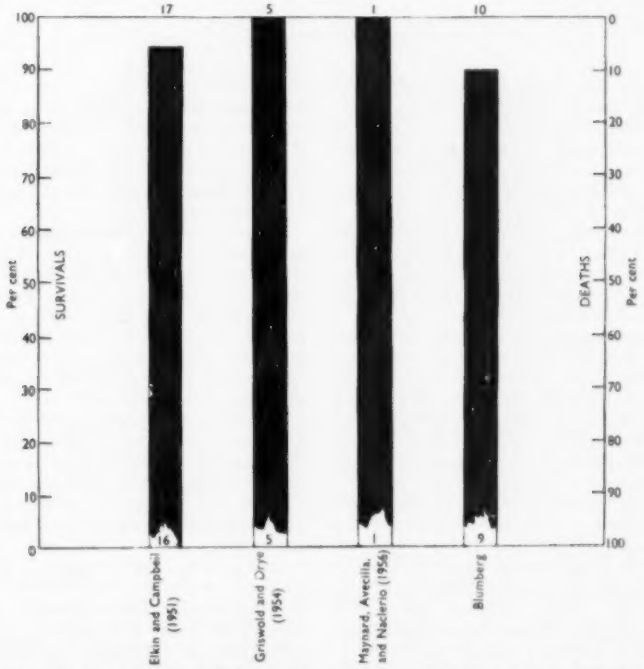


Fig. 699.—The figures on the bottom line indicate the number of cases who survived. The figures on the top line indicate the total number of cases.

from hospital. One patient (*Case* 6) was seen 5 months later. The patients were all apparently well and would probably have reported back had they not remained so. Drye, Coe, and Stamer (1956) followed 20 cases treated by operation over periods of 3 to 20 years. In no case did they find a lesion which could be attributed to the cardiac wound. With conservative treatment, however, the incidence of complications appears to be high. They are, delayed hæmorrhage, cardiac aneurysm, constrictive pericarditis, suppurative pericarditis, damage to a coronary vessel (Crastnopol and Mannix, 1955).

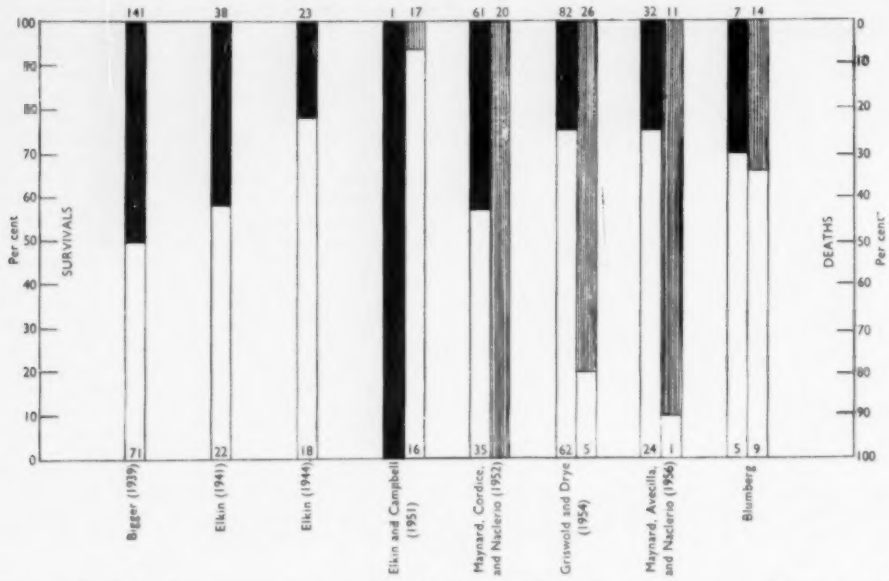


FIG. 700.—The dark columns represent cases treated by operation; the lighter columns represent cases who were not subjected to surgery. The figures on the bottom line indicate the number of cases which survived, and the figures on the top line indicate the total number of cases.

Delayed Hæmorrhage.—In the present series *Cases* 8 and 9 developed this complication, in the latter case with a disastrous result. Mason, Warshauer, and Williams (1955) reported a case of delayed hæmorrhage six days after injury.

Cardiac Aneurysm.—No cases occurred in the present series. Lyons and Perkins (1958) reported the development of a cardiac aneurysm after suture of a ventricular wound. They explained its occurrence by improper closure of the wound, or the presence of a second, overlooked laceration. This is the only case with a long-term complication after operation which was found in the literature.

Constrictive Pericarditis.—This is the commonest late complication. It has only been reported after conservative treatment (Best, 1954; Maynard and others, 1956). It is the direct result of hæmopericardium and has occurred with closed injuries. Ehrenhaft and Taber (1952), quoting extensively from the literature, cite cases following non-penetrating chest injuries and report a case of their own. There are reports by Ada, Jones, and Sheeran (1950), Glenn (1940), Skinner and Farr (1953). Overholt, Burwell, Woodbury, and Walker (1952) reported a case of constrictive pericarditis plus pleural thickening, following a closed injury. All these cases were treated by pericardiectomy, and in the patient of Overholt and others a bilateral pulmonary decortication was performed as well. One of Elkin and Campbell's (1951) patients developed a recurrent pericardial effusion and was treated by aspiration.

Suppurative Pericarditis and Coronary Vessel Damage.—These are complications of pericardial aspiration.

The Post-pericardiotomy Syndrome.—This little-known syndrome has been seen after conservative treatment (Segal and Tabatznik, 1959). It is characterized by pleuropericardial pain, pericardial and pleural effusions, pyrexia, and a tendency to relapse. The syndrome is similar to the post-commissurotomy syndrome which may complicate mitral valvotomy. It may appear several weeks or months after the initial trauma.

Choice of Treatment.—The view of most workers is that cases in Groups 3 and 4 should be subjected to surgery as soon as possible. The results in the present and other series suggests that Group 2 cases should also be operated upon. Because of myocardial softening and subsequent problems with suture (*Case* 1), and the danger of delayed hæmorrhage (*Case* 9), early surgery is advocated in patients admitted with cardiac tamponade, even where this has improved on initial therapy. This agrees with the view of Griswold and Maguire (1942), who state: "If tamponade is serious enough to require aspiration, open operation with wound suture and drainage of the pericardium is the treatment of choice."

Group 1 cases should be treated conservatively. The effusions absorb readily and it is unnecessary to aspirate them. Such cases have not reported back with constrictive pericarditis. An interesting feature in some of the cases treated conservatively is the rapidity with which the effusion sometimes absorbs (*Cases* 8, 10, 11, and 13). This is unlike the behaviour in cases which undergo operation. The reason is not clear. The quality of the effusion probably varies with the severity of the injury. It is unlikely that rapidly-clearing effusions will lead to constrictive pericarditis. Further investigation into the properties of the effusions may produce information which will make the indications for treatment more precise.

Management of Severe Cases.—Of the fatal cases in the present series, *Cases* 18–21 had massive hæmorrhage. One patient survived for 20 min. The practice of rushing such cases up to the ward as 'urgent directs' is to be condemned. Such cases should be diagnosed and receive their initial treatment in the casualty department, where the medical officer must decide whether he is dealing with a case of hæmorrhage or tamponade. Generally, the cases with hæmorrhage are more urgent problems than those with tamponade. *The most important physical sign of tamponade is venous congestion*, and this must always be looked for. *It is often possible to introduce a needle into an antecubital vein without the need for a proximal tourniquet, despite a blood-pressure below 60 mm. of mercury* (Kay, 1959).

Whether the picture is one of hæmorrhage or tamponade, blood must be immediately given. Two or more simultaneous transfusions may be necessary and the blood should be given under pressure if the patient's general condition is poor. Intra-arterial transfusions were not employed pre-operatively in any of the cases reported here, but they are worth considering.

Where there is tamponade, the pericardium should be aspirated, as a preliminary to surgery. If there is a large hæmothorax, this should be relieved, to allow re-expansion of the lung. The patient must be oxygenated, and if he is unconscious an endotracheal tube should be passed and oxygen pumped in from an anæsthetic machine.

Whilst this treatment is being given, the operating theatre should be prepared. *It would be sound practice to send the patient direct from casualty to the theatre, short-circuiting the ward.* There should be the shortest possible delay before operating. Both surgeon and anæsthetist must be fully aware that the case is a poor risk. The patient's condition may never become satisfactory, and *there should be no procrastination, waiting for the blood-pressure to rise.* The operation is often commenced under oxygen only. After the hole has been closed, the general condition usually improves dramatically and anæsthetic drugs are then added.

The operation and after-care have already been discussed.

SUMMARY

Twenty-one cases of stab wounds of the heart are reported and the literature is reviewed. The mortality in this series was 32 per cent. Recovery with operation was 71·4 per cent and in cases not subjected to operation it was 66·7 per cent.

The pathology and diagnosis are described.

The methods, merits, and disadvantages of conservative and operative treatment, and the indications for each, are discussed.

It is concluded that mild cases should be treated conservatively, and severe cases subjected to operation, even though they may respond to initial conservative treatment.

Acknowledgements.—I wish to thank Dr. Elliot, Medical Superintendent of Coronation Hospital, Johannesburg, for permission to publish these cases; and Dr. J. Friedman, Senior District Surgeon, Johannesburg, for giving me access to the autopsy records and allowing me to publish the findings. My thanks are also due to Mr. C. D. Kisner and Mr. S. Kay, of Johannesburg, for their invaluable criticisms and suggestions. For the excellent survival rate with surgery, credit is due to Mr. S. Kay, who operated on *Cases* 2–4, and Mr. B. Lewin, who operated on *Cases* 1, 5, and 6. My thanks are also due to the Photographic Unit, Department of Medicine, for *Figs.* 692–695, and Mr. D. Smith, of the Department of Surgery, for the remaining photographs.

REFERENCES

ADA, A. E. W., JONES, O. R., and SHEERAN, A. D. (1950), *J. thorac. Surg.*, **20**, 105.
BECK, C. S. (1926), *Arch. Surg., Chicago*, **13**, 205.
BELL, L. C. (1957), *Brit. med. J.*, **2**, 31.
BEST, T. C. (1954), *N. C. med. J.*, **15**, 13.
BIGGER, I. A. (1939), *J. thorac. Surg.*, **8**, 239.
COOLEY, D. A., DUNN, J. R., BROCKMAN, H. Le R., and DEBAKEY, M. E. (1955), *Surgery*, **37**, 882.
COOPER, F. W., jun., STEAD, E. A., jun., and WARREN, J. V. (1944), *Ann. Surg.*, **120**, 822.
CRASTNOPOL, P., and MANNIX, E. P. (1955), *Surgery*, **37**, 840.
DRYE, J. C., COE, W. S., and STAMER, J. P. (1956), *Amer. J. Surg.*, **24**, 355.
EHRENHAFT, J. L., and TABER, R. E. (1952), *J. thorac. Surg.*, **24**, 355.
ELKIN, D. C. (1941), *Ann. Surg.*, **114**, 169.
— — (1944), *Ibid.*, **120**, 817.
— — and CAMPBELL, R. E. (1951), *Ibid.*, **133**, 623.
GLENN, E. C. (1940), *J. Mo. St. med. Ass.*, **37**, 7.
GRISWOLD, R. A. and MAGUIRE, C. H. (1942), *Surg. Gynec. Obstet.*, **74**, 406.
— — and DRYE, J. C. (1954), *Ann. Surg.*, **139**, 783.
GRUSIN, H. (1954), *Circulation*, **9**, 860.
KAY, S. (1959), personal communication.
LAWRIE, R. W. (1955), *Brit. med. J.*, **1**, 952.
LYONS, C., and PERKINS, R. (1958), *Ann. Surg.*, **147**, 256.
MASON, L. B., WARSHAUER, S. E., and WILLIAMS, R. W. (1955), *J. thorac. Surg.*, **29**, 524.
MAYNARD, A. de L., CORDICE, J. W. V., and NACLERIO, E. A. (1952), *Surg. Gynec. Obstet.*, **94**, 605.
— — AVECILLA, M. J., and NACLERIO, E. A. (1956), *Ann. Surg.*, **144**, 1018.
NOTH, P. H. (1946), *Amer. Heart J.*, **32**, 713.
OVERHOLT, R. H., BURWELL, C. S., WOODBURY, J. W., and WALKER, J. H. (1952), *J. thorac. Surg.*, **23**, 1.
SEGAL, F., and TABATZNIK, B. (1959), *Amer. Heart J.*, **59**, 175.
SKINNER, H. L., and FARR, K. F. (1953), *J. Amer. med. Ass.*, **152**, 235.

TWO CASES OF URETERIC TUMOUR WITH UNUSUAL PYELOGRAPHIC FINDINGS

By L. STUART SCOTT
UROLOGICAL DEPARTMENT, ROYAL BEATSON MEMORIAL HOSPITAL, GLASGOW

AND A. DOUGLAS ROY
A SURGICAL UNIT, WESTERN INFIRMARY, GLASGOW

As the clinical and pathological aspects of ureteric tumours have already been adequately described in a series of papers by McAlpine (1947), these 2 cases are presented as a demonstration of some of the difficulties connected with their diagnosis and to show, once again, the importance of *complete* urological investigation in all cases of hæmaturia. Until recent years, primary tumours of the ureter were considered rare (Gualtieri, Hayes, and Segal, 1948; Edelstein and Marcus, 1948), but it is now recognized (Lund and Lundwall, 1956) that this is not so. It is presumed that the apparent increase in frequency of these tumours is due primarily to improved diagnostic techniques; 5 such tumours were encountered in the Urological Department of the Western Infirmary, Glasgow, in the past two years.

FIG. 701.—*Case* 1. Retrograde pyelogram.

CASE REPORTS

Case 1.—A man, aged 62 years, was admitted to a general surgical unit at the Western Infirmary in June, 1958, for repair of an umbilical hernia. Five days after operation he developed painless hæmaturia which continued intermittently for several days. He had no previous history of hæmaturia.

FIG. 702.—*Case* 1. Operation specimen showing hydronephrosis and hydro-ureter.

FIG. 703.—*Case* 1. The kidney and ureter opened to show the two tumours.

ON EXAMINATION.—When the urine cleared, red blood-cells could still be detected on microscopy but there were no pus cells or organisms in a stained film and no growth on culture.

Intravenous pyelography showed normal excretion of dye from a healthy-looking right kidney, but no evidence of dye was seen on the left side.

FIG. 704.—*Case* 2. Intravenous pyelogram.

Cystoscopy revealed a healthy bladder. The right ureteric orifice looked normal, but the left one was surrounded by an area of hyperæmia. The right ureteric efflux was clear; the left was 'muddy'. Bilateral catheterization of the ureters was attempted; the right catheter passed to 25 cm. without obstruction, but the left one was held up at 13 cm. and attempts to manipulate it beyond this resulted in bleeding.

Retrograde pyelography showed a normal right kidney and ureter, but the appearances on the left side (*Fig.* 701) led to controversy between the radiologist and the urologist. The former believed that the appearances indicated a congenital ectopic kidney, whereas the latter considered that the complete absence of caliceal formation suggested complete ureteric obstruction.

AT OPERATION.—Laparotomy was performed by one of us (L. S. S.) and a thickened fusiform swelling in the lower third of the left ureter was found. Tracing the ureter upwards revealed palpable thickening—to the size of the index finger—as far as the exploring hand could reach. Nephro-ureterectomy was performed.

THE SPECIMEN.—Naked-eye examination of the specimen showed a hydronephrotic kidney (*Fig.* 702) with associated hydro-ureter in the upper two-thirds.

When the specimen was bisected (*Fig.* 703) a papillary tumour was found at the upper end of the ureter; the renal pelvis was dilated but not involved in tumour. Tracing downwards, there was a clear, kinked portion of ureter with, below it, a second papillary tumour extending for 10 cm. and ending abruptly.

Histological examination of both tumours showed that they were transitional-cell carcinomata of the ureter with deep invasion of the wall. Tumour cells were also seen in the lymphatics and peri-ureteric fat.

Case 2.—A man, aged 51 years, was admitted to the same general surgical unit in October, 1958, with clot retention following 36 hours of hæmaturia. Low back pain had been present for two weeks, but he had no previous history of hæmaturia. The urine cleared after 48 hours of indwelling catheter drainage and, although red cells could still be detected microscopically, there were

FIG. 705.—*Case* 2. Retrograde pyelogram.

FIG. 706.—*Case* 2. Operation specimen; ureter opened to show the papillary tumour.

no pus cells or organisms in a stained film and no growth on culture.

ON EXAMINATION.—Intravenous pyelography showed normal excretion of dye from both kidneys and no filling defects were noted (*Fig.* 704).

Cystoscopy revealed healthy bladder mucosa. The right ureteric orifice was normal in appearance but the left one was pouting and œdematous. The urinary efflux was clear on both sides and the left ureter was catheterized to 25 cm. without obstruction.

Left retrograde pyelography showed a previously undetected fusiform dilatation of the middle-third of the ureter with a filling defect in its centre (*Fig.* 705).

Cytology of the urinary sediment collected from the left ureteric catheter showed "numerous blood-cells and clumps of epithelial cells consistent with origin in a papillary tumour".

A diagnosis of ureteric tumour was made and confirmed at laparotomy by one of us (A. D. R.). Left nephro-ureterectomy was performed.

THE SPECIMEN.—Naked-eye examination of the bisected specimen (*Fig.* 706) revealed a healthy kidney and renal pelvis; in the middle third of the ureter was a papillary tumour.

Histological examination of the tumour showed that it was a highly cellular transitional-cell papilloma with occasional mitoses and a moderate degree of pleomorphism.

DISCUSSION

In the first case the retrograde pyelogram was deceptive in that the smooth contour of the obstructed ureter gave a picture which was considered by the radiologist to be diagnostic of ectopic kidney rather than ureteric tumour and, as such, laparotomy might well have been delayed indefinitely. As it was, reasonable doubt—coupled with an instinctive distrust of the diagnosis of *essential hæmaturia*—led to prompt treatment with, so far, no evidence of recurrence or metastases.

In the second case it was the intravenous pyelogram that was deceptive; retrospective scrutiny of the films *after* operation still failed to show any definite abnormality in the affected ureter which could not be reasonably attributed to abdominal compression. These films were accepted by the radiologist as being normal and, when coupled with the œdematous appearance of the left ureteric orifice on cystoscopy, a diagnosis of recently-passed calculus might well have been considered adequate. Cytology of the urine collected from the ureteric catheter was a further aid in this case, which again demonstrates the necessity of pursuing the investigation of hæmaturia until a satisfactory explanation is obtained.

SUMMARY

Two cases of ureteric tumour with short histories of hæmaturia and misleading pyelographic findings are presented. The fallacies of accepting a diagnosis of 'essential hæmaturia' without *complete* investigation are again demonstrated.

Acknowledgements.—We wish to thank Mr. W. S. Mack and Mr. A. B. Kerr—in whose Urological and Surgical Units, respectively, these patients were treated—for permission to publish the case records; also Dr. A. T. Sandison for the cytological report on *Case* 2. The illustrations of *Case* 1 were produced by Mr. Breslin at the Clinical Photographic Department of the Beatson Memorial Hospital, and of *Case* 2 by Mr. Gabriel Donald at the Department of Medical Illustration of the Western Infirmary; to both of them we are gratefully indebted.

REFERENCES

EDELSTEIN, J. M., and MARCUS, S. M. (1948), *J. Urol.*, **60**, 409.
GUALTIERI, T., HAYES, J. J., and SEGAL, A. D. (1948), *Ibid.*, **59**, 1083.
LUND, F., and LUNDWALL, F. (1956), *Brit. J. Urol.*, **28**, 137.
MCALPINE, J. B. (1947), *Brit. J. Surg.*, **35**, 113.

EXPERIMENTAL SURGERY

MECHANISMS PREVENTING GASTRO-ŒSOPHAGEAL REFLUX IN THE DOG

BY F. G. SMIDDY AND M. ATKINSON
FROM THE DEPARTMENTS OF SURGERY AND MEDICINE, THE UNIVERSITY OF LEEDS

WHILST it is generally agreed that prolonged contact between gastric contents and the œsophageal mucosa leads to an erosive œsophagitis, there is no such concordance of opinion about the mechanisms at the cardia which normally prevent gastro-œsophageal reflux. A true sphincter intrinsic to the œsophago-gastric junction, a mechanical flap-valve formed by the acute angle of entry of the œsophagus into the stomach, and extrinsic compression by the crura of the diaphragm have each in turn been put forward as the principal mechanism preventing reflux. Even to the present day each of these mechanisms has its protagonists, who too often dismiss the others as being of little consequence.

Although an anatomical sphincter at the œsophagogastric junction was described by Baillie in 1807, subsequent studies have failed to provide convincing morphological evidence of its presence, and it is on this account that controversy has arisen about the existence of an intrinsic sphincter at the lower end of the œsophagus. Lendrum (1937) was unable to demonstrate such a sphincter, although Lerche's (1950) dissections indicated a mechanism comprising two sphincters which he named the lower œsophageal sphincter and the constrictor cardiæ, situated at the upper and lower ends respectively of a narrow channel or vestibule separating the stomach from œsophagus. Physiological studies

leave no such room for doubt, however, and manometric methods clearly demonstrate a sphincter at the human œsophagogastric junction, recognizable as a localized zone in which the intraluminal pressure is increased by tonic sphincteric contraction (Fyke, Code, and Schlegel, 1956; Botha, Astley, and Carre, 1957; Atkinson, Edwards, Honour, and Rowlands, 1957 a). As such a mechanism can still be found at the cardia when this is displaced upwards into the chest as a result of hiatus hernia (Atkinson and others, 1957 b), the presence of a physiological intrinsic sphincter at the human cardia can be accepted without further hesitation.

The second factor, a mechanical flap-valve related to the acute angle of entry of the œsophagus into the stomach, was first emphasized by von Gubaroff (1886), although it is more commonly known as the angle of His (1903). This angle must be maintained by an active mechanism since it disappears after death (Atkinson and Sumerling, 1959). Anatomically there would appear to be two possible means by which this angle might be maintained. First, it might be by the arrangement of the oblique gastric muscle-fibres which condense on the left side of the œsophagogastric junction to form a sling. This sling was originally described by Willis (1674) and was later considered by Lendrum (1937) and Barrett (1952, 1954) to be of primary importance in the maintenance of the angle. Secondly, the angle might be maintained by the external support of the right crus of the diaphragm, which is attached by the phreno-œsophageal ligament to the lower end of the œsophagus. Collis, Kelly, and Wiley (1954), Peters (1955), and Marchand (1955) advocate the view that the œsophagogastric angle is preserved by such external support.

Many believe that the diaphragm fulfils not only the passive supportive role already described but also compresses the œsophagogastric junction directly. This pinchcock action, described by Jackson (1922) as a result of his endoscopic observations, forms the third major factor which has been considered important in the prevention of gastro-œsophageal reflux. This view received strong support from Allison (1951), who likened the action of the right crus to that of the puborectalis at the other extremity of the gastro-intestinal tract. Wooler (1952) noted that stimulation of the phrenic nerve at thoracotomy caused a finger inserted into the hiatus to be tightly gripped, but Dornhorst, Harrison, and Pierce (1954) were unable to detect such constriction during respiratory contraction. O'Mullane (1954) found that the cardia retained its competence when the diaphragm was completely paralysed by muscle relaxants during the course of anæsthesia, which would suggest that the diaphragm does not serve to prevent reflux.

One further factor must briefly be considered: Magendie (1813) believed that a rosette formed by mucosal folds occluded the cardia. Botha (1958), after dissection of the cardia in various animal species, considered that this mucosal rosette, actively supported by the muscularis mucosæ, was an important factor in itself. Allison's comment (1956) that "anyone old enough to have actually ridden in a (horse-drawn) cab knows that a mucosal lined tube big enough to allow the passage of a mass will, when closing, form a rosette" is pertinent to this point.

The paucity of experimental work designed to assess the contribution of each of these various mechanisms to the competence of the cardia led us to investigate this problem in the dog. The present study was made to determine the effects of disruption of the intrinsic cardiac sphincter, the oblique gastric fibres, and the right crus of the diaphragm, singly and in various combinations, upon the cardia's resistance to reflux, and to determine whether reflux œsophagitis followed any of these operative procedures.

METHODS

Manometric Studies.—Mongrel dogs weighing between 10 and 15 kg. were used. Under oxygen-ether anæsthesia œsophagoscopy was performed and a polyvinyl tube placed in the œsophagus so that its tip lay 3 cm. above the cardia. Aspiration through this tube served to detect reflux of gastric contents during subsequent manipulation. The abdomen was then opened and a rubber catheter inserted into the gastric lumen via an incision in the anterior gastric wall. Through the catheter the stomach was distended with water coloured with gentian violet to facilitate its detection in the œsophageal aspirate. Intragastric pressure was measured by means of a simple water manometer attached to the catheter, taking the level of the cardia as zero point. Intragastric pressure was slowly increased by distending

FIG. 707.—Dissection of the dog's stomach to show the oblique muscle-bundle, the sling of Willis. The stomach has been turned inside out and the mucosa and submucosa dissected from the posterior wall.

the stomach with fluid until gastric contents entered the œsophagus, and the pressure at which this occurred (yield pressure) was noted. At least three measurements of the yield pressure were made in each dog before interference with structures around the cardia.

One of the three following operations was then performed and measurements of the yield pressure were repeated.

Operative Procedures.—

1. *Cardiomyotomy.*—In 3 dogs the cardiac sphincter was destroyed by making a longitudinal incision in the medial wall of the œsophagus upwards for 4 cm. from the œsophagogastric junction. The incision passed through the muscular layers down to the mucosa. This operation was also performed in two other dogs which had previously undergone section of the oblique gastric fibres (operation 3).

2. *Section of the Diaphragmatic Crura.*—In 6 dogs the crural fibres of the diaphragm on both sides of the hiatus were sectioned. This operation was carried out in 5 additional dogs which had already undergone cardiomyotomy (operation 1) and in these animals the left dome of the diaphragm was incised to free the cardia completely.

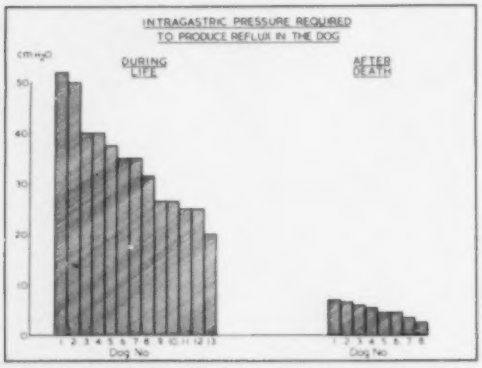


FIG. 708.—Intragastric pressure required to produce reflux in 13 dogs during life and 8 dogs after death. After death the cardia loses its resistance.

3. *Section of the Oblique Gastric Muscle-fibres.*—Preliminary dissections showed that the oblique gastric fibres in the dog form a distinct bundle looping around the œsophagogastric angle (*Fig.* 707). In 4 dogs these fibres on the anterior and posterior walls of the stomach just below the cardia were destroyed by making transverse incisions down to the mucosa. Careful dissection was required to disrupt these fibres, which were often firmly attached to the mucosa. This procedure was carried out in a further 9 dogs; in 5 of these cardiomyotomy (operation 1) and diaphragmatic section (operation 2) had already been performed, in the other 4 diaphragmatic section alone had been carried out previously.

For comparative purposes measurements of the yield pressure of the cardia were made in 8 dogs approximately 4 hours after death.

Radiological Studies.—To determine whether any of the three procedures described above caused alteration of the angle at which the œsophagus joins the stomach, radiographs were taken after distension of the stomach with a barium suspension (micropaque). In each of three dogs studied in this way, films were taken before interference, after cardiomyotomy, after section of the diaphragm, and after section of the oblique fibres, in this sequence. *Electromyographic* records from the hiatal muscle of the diaphragm were obtained in one dog during progressive distension of the stomach by the method previously described.

Late Effects of These Operations on the Cardia.—Search for œsophagitis by repeated œsophagoscopy was made during 'follow-up' periods ranging from 4 to 6 months after cardiomyotomy (3 dogs), section of the oblique fibres (3 dogs), or section of the diaphragm (3 dogs). At the end of the 'follow-up' period the yield pressure of the cardia was measured again and the dog was then sacrificed to obtain its œsophagus for histological examination.

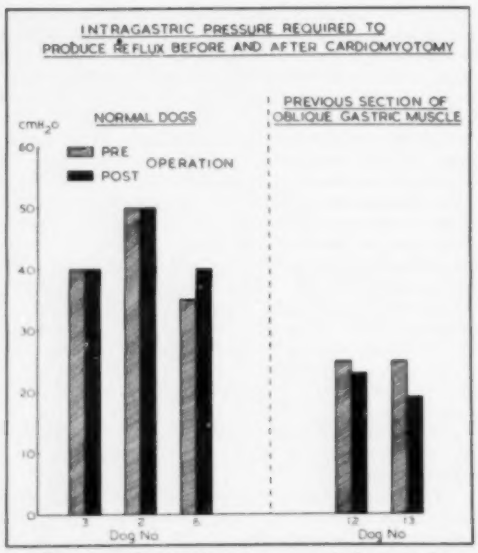


FIG. 709.—Intragastric pressure required to produce gastro-œsophageal reflux before and after cardiomyotomy. This operation had little effect upon the competence of the cardia to prevent reflux.

RESULTS

The Resistance of the Normal Cardia (*Fig.* 708).—Measurements of the intragastric pressure necessary to produce reflux were made in 14 dogs. In each, the cardia resisted flow into the œsophagus, the yield pressures varying between 20 and 55 cm. H_2O, with a mean of 34 cm. H_2O. Once the cardiac mechanism had been forced the stomach continued to empty, even though intragastric pressure was allowed to fall, and it appeared that reflex relaxation of the closing mechanisms had taken place. A few minutes after emptying had ceased the cardia regained its competence and the yield pressure could be estimated again. Repeat measurements on each individual dog gave readings which always corresponded to within 10 cm. H_2O, and usually to within 5 cm. It was observed repeatedly that manipulation of the stomach whilst these measurements were being

made caused reflux to occur at much lower intragastric pressures. Distortion of the normal œsophagogastric angle was apparently the cause of this loss of cardiac competence.

That the mechanism preventing gastro-œsophageal reflux in these dogs was an active one was indicated by the findings in 8 dogs studied after death (*Fig.* 708). Here the yield pressure never exceeded 7 cm. H_2O, and averaged 5 cm. H_2O.

The Effect of Cardiomyotomy (Operation 1).—In none of the three dogs subjected to cardiomyotomy (*Fig.* 709) did the yield pressure of the cardia show significant change, nor was any striking alteration seen in the two further dogs subjected to

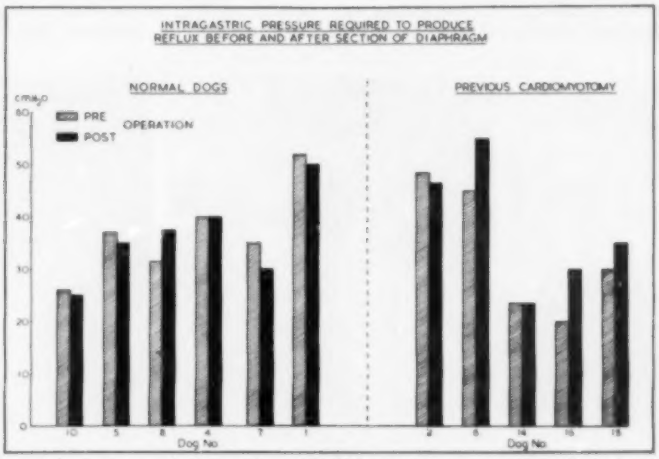


FIG. 710.—Intragastric pressure required to produce reflux before and after section of the diaphragmatic crural fibres. This operation appeared to have little effect on the competence of the cardia.

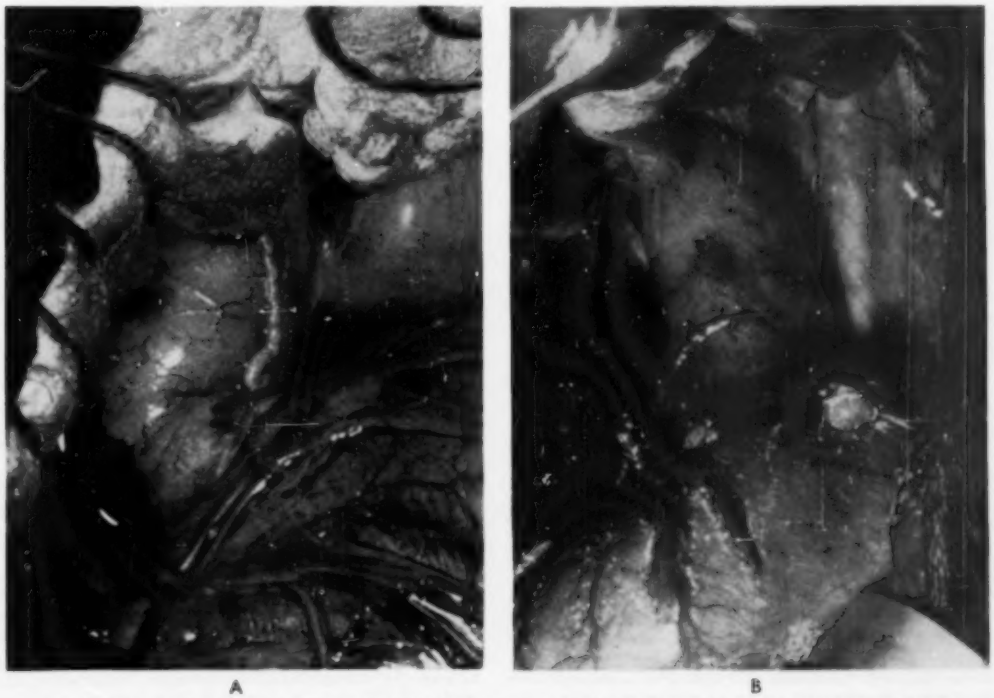


FIG. 711.—Photographs taken at operation in the dog showing in A that the œsophagogastric angle is maintained in spite of freeing the cardia from its extrinsic attachments. B shows the loss of this angle after section of the oblique muscle-bundle.

cardiomyotomy three months after section of the oblique gastric fibres. Under the conditions of these experiments at least, it seemed unlikely that the cardiac sphincter was contributing to the prevention of reflux.

The Effect of Section of the Diaphragm (Operation 2).—In 6 dogs measurements of the yield pressure of the cardia were made before and after section of the hiatal muscle. Little change in the resistance to reflux was noted after this operation and in none of the dogs did the yield pressure diminish by more than 5 cm. of water (*Fig.* 710).

The effect of section of the diaphragm was observed in a further 5 dogs which had previously undergone cardiomyotomy, and in these, in addition to severing the crural muscle, the left diaphragm was completely divided by an incision carried across its dome. The stomach and œsophagogastric junction were allowed to protrude upwards through the transected diaphragm so as to lie in the chest. In 2 of these dogs the resistance of the cardia appeared to be enhanced by diaphragmatic transection and the yield pressure increased in each by 10 cm. H_2O; in the remaining 3 dogs no striking change in the yield pressure followed the operation.

The œsophagogastric angle appeared to be well maintained in these dogs when the region of the œsophagogastric junction and fundus of the stomach were completely isolated from the surrounding structures (*Fig.* 711 A), and radiographs taken after distension of the stomach with barium confirmed that the œsophagogastric angle appeared to be maintained after diaphragmatic section (*Fig.* 712 B).

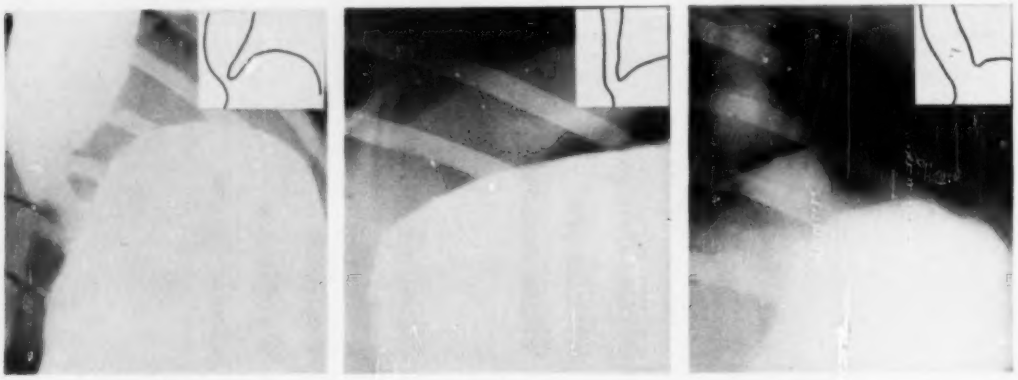


FIG. 712.—Radiographs taken after distension of the dog's stomach with barium. A shows the normal œsophagogastric angle before surgical interference; B that an angle is still present after complete section of the hiatal and diaphragmatic muscle; and C, reduction in the angle after section of the oblique muscle-fibres.

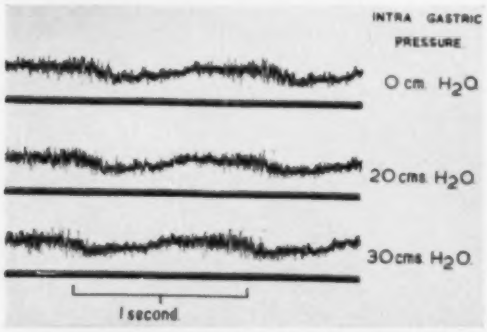


FIG. 713.—Electromyographic study of the muscular activity of the crural fibres of the diaphragm during progressive increase in intragastric pressure. The respiratory activity of the crural fibres is shown, but there is no superadded electrical activity observable when the intragastric pressure is increased towards the normal yield pressure of the cardia, indicating that increased contraction of the hiatal muscle-fibres does not occur.

Electromyography.—Electromyographic records of the muscular activity of the intact crural fibres of the diaphragm obtained during distension of the stomach are shown in *Fig.* 713. The respiratory contractions are visible as bursts of increased electrical activity in inspiration. However, no overall increase in muscular activity during either phase of respiration could be detected by this means during progressive distension of the stomach, implying that the crura of the diaphragm did not function to prevent reflux by contracting more tightly when the cardia was subjected to an increasing intragastric pressure.

The Effect of Section of the Oblique Gastric Fibres (Operation 3).—The oblique gastric fibres were sectioned in 13 dogs in all; it was the primary procedure in 4 and followed section of the diaphragm with or without cardiomyotomy in 9 dogs. The yield pressure of the cardia was reduced by section of the oblique gastric fibres in 12 of the 13 dogs and in 10 it fell to 15 cm. H_2O or less (*Fig.* 714). The mean initial yield pressure in the group was 31 cm. H_2O, and this fell to 14 cm. H_2O after the operation. Thus, in obvious contrast to cardiomyotomy and section of the diaphragm, disruption of the oblique gastric fibres caused gross impairment of the resistance of the cardia to gastro-œsophageal reflux.

Even when the diaphragm had been incised so as to free the stomach and œsophagus completely, the angle of His was maintained (*Fig.* 711 A) and the cardia retained its resistance to reflux. However,

disruption of the oblique gastric fibres caused partial or complete loss of the œsophagogastric angle (*Fig.* 711 B). Radiographs taken after distension of the stomach with barium confirmed that this angle was no longer acute (*Fig.* 712 C). Loss of this angle appeared to go together with loss of competence of the cardia; if section of the oblique fibres was incomplete the angle was maintained and the cardia the cardia to reflux and, as we have shown, gives reproducible results, the yield pressure remaining remarkably constant after prolonged manipulation of the viscera. Therefore the findings obtained cannot be explained on the basis of temporary loss of muscle tone brought about by this means.

A more difficult factor to assess was the effect of anæsthesia. It is conceivable that this may have

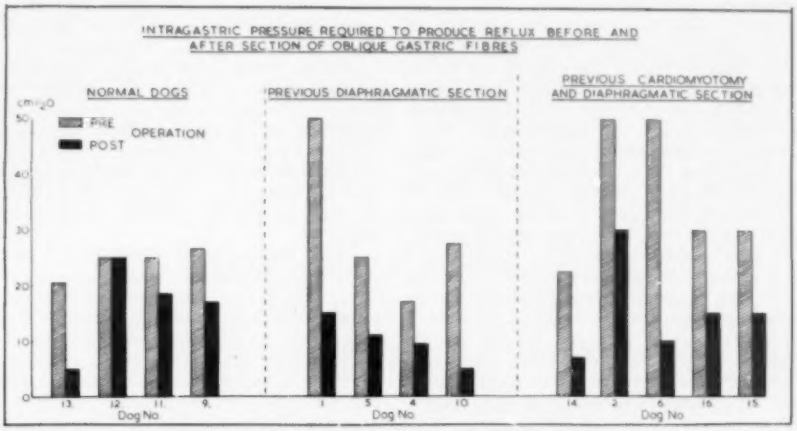


FIG. 714.—Intragastric pressures required to produce reflux before and after section of the oblique muscle-fibres. The cardia's resistance to reflux is considerably reduced after this operation.

retained its competence. Further dissection usually revealed intact fibres, section of which led to loss of the angle and reduction in the yield pressure. A few remaining fibres were often sufficient for the cardia to retain a remarkable degree of competence.

Additional evidence that the angle of His is maintained by a mechanism intrinsic to the stomach was obtained when the lower œsophagus and stomach were removed intact from 2 living dogs. At first the angle persisted but then gradually disappeared until it was no longer detectable 5 minutes after severance of the gastric blood-supply (*Fig.* 715).

Late Effects.—In no dog was œsophagitis detected by œsophagoscopy during periods of observation of 4–6 months or at autopsy, following the three operative procedures described above.

At the time of sacrifice of the dogs repeat measurements of the yield pressure of the cardia were made and little change was noted in those which had undergone cardiomyotomy or diaphragmatic section. But in those dogs which had been subjected to section of the oblique fibres with consequent reduction in the resistance of the cardia, the yield pressure was found to have risen again often to its initial level. Exploration revealed intense fibrosis around the cardia and in fact one of these animals developed dysphagia as a result of constriction of the œsophagogastric junction by scar tissue. This fibrosis seemed the probable explanation of the return of competence to the cardia and the absence of œsophagitis in these dogs.

FIG. 715.—Photograph of the dog's stomach and lower œsophagus taken 10 min. after death, showing complete loss of the œsophagogastric angle.

DISCUSSION

The manometric method used in this study provides a quantitative estimate of the resistance of

caused relaxation of the cardiac sphincter and thus led us to underestimate the importance of this structure in preventing reflux under more physiological conditions; in a few intact anæsthetized dogs in which intraluminal pressure measurements were made, no sphincteric zone could be detected. But the factor of anæsthesia did not appear to impair the action of the crura since active respiratory contractions of the diaphragm continued throughout the period of operation in all the dogs.

Previous work upon the closing mechanisms of the canine cardia has given conflicting results. Nauta (1956), using a similar method of distension of the stomach of a single anæsthetized dog, found that a pressure of 100 cm. of water was required to force gastric contents into the œsophagus, a level almost twice that found in any of our animals. After severing the hiatal muscle of the diaphragm in this dog he found that the yield pressure fell to 30 cm. of water and, therefore, concluded that the diaphragm was of considerable importance in preventing reflux. On the other hand, Braasch and Ellis (1956) found that the dog's stomach and œsophagus could be transplanted so that the cardia lay either in the thorax or in the abdomen well below the hiatus, without œsophagitis occurring. Our findings provide further evidence that in the dog the diaphragm does not contribute towards closure of the cardia or even play a major part in maintaining the acute œsophagogastric angle.

Other experimental studies in the dog have indicated that the intrinsic sphincter at the œsophagogastric junction is of prime importance in the prevention of reflux. Hoag, Kiriluk, and Merendino (1954) found that so long as the region of the physiological sphincter was left intact, reflux œsophagitis did not develop after obliteration of the gastro-œsophageal angle. However, œsophagitis developed even after removal of 100 per cent of the parietal cells when the sphincter area was resected. Braasch and Ellis observed œsophagitis after cardiomyotomy as well as after the Wendel procedure and œsophagogastrectomy. The two latter procedures are likely to affect the œsophagogastric angle and to favour reflux on this account. Cardiomyotomy should not be open to this objection and the appearance of reflux after this operation would provide strong evidence that the intrinsic sphincter is the principal mechanism preventing reflux. However, we were unable to confirm this observation in our animals, nor did we observe any change in the yield pressure of the cardia after cardiomyotomy.

Although we were unable to demonstrate any contribution of the cardiac sphincter or the diaphragm to the cardia's resistance to reflux, our findings did emphasize the importance of the oblique gastric muscle-fibres, complete section of which consistently lowered the resistance of the cardia to reflux. Thus, after complete division of these fibres reflux could be produced by intragastric pressures little greater than those required in the cadaveric dog. Hence, we conclude that the oblique gastric fibres appear to be the major mechanism preventing reflux, which function they fulfil by maintaining the acute œsophagogastric angle. As this angle was unaffected by severance of the diaphragmatic crura and was increased by transection of the left diaphragm, which allowed the fundus of the stomach to rise into the thorax, it seems probable that the maintenance of the angle is solely a function of the gastric musculature itself rather than the extra-gastric supporting structures, such as the diaphragm. The loss of the angle which we noted after section of the oblique gastric fibres bears out this contention. Further support for this view is provided by the observation that when the lower œsophagus and stomach are removed intact from the anæsthetized dog, they retain their usual configuration for a few minutes before the œsophagogastric angle disappears.

Other investigators disagree about the importance of the angle of His in the prevention of reflux; Hoag and others (1954) and Botha (1958) dismiss it as having no part in the normal closing mechanisms, whereas Adler and Firme (1958) emphasize its importance and in dogs with surgically produced hiatus hernias were able to increase the competence of the cardia by plastic reconstruction of the angle.

The absence of œsophagitis in our dogs, after section of the oblique fibres had greatly reduced the resistance of the cardia, was surprising. But as the yield pressures, when measured by the same technique 4–6 months after operation, had risen to pre-operative levels, the cardia must have regained a degree of competence. This we assume to be due to the intensive fibrosis around the site of operation. However, the absence of œsophagitis does not necessarily imply that no reflux was taking place in these dogs; Ripley, Leary, Grindlay, Seybold, and Code (1950) found that even after transplantation of gastric mucosa into the œsophagus or anastomosis of the gastric fundus to the œsophagus, injections of histamine in beeswax were required to precipitate mucosal changes.

SUMMARY

The contribution of the cardiac sphincter, the diaphragm, and the oblique fibres of the gastric wall to the competence of the dog's cardia has been investigated by observing the effect of disruption of each of these structures upon the cardia's resistance to reflux during progressive gastric distension. Neither cardiomyotomy nor section of the diaphragm had any demonstrable effect on the cardia's resistance to reflux. Section of the oblique gastric fibres, however, led to loss of the acute angle of entry of the œsophagus to the stomach and resulted in reflux occurring at a much lower level of intragastric pressure. It is concluded that the acute angulation of the œsophagogastric junction in the dog is maintained by the oblique gastric fibres rather than by external support from the diaphragm, and that this angle forms the major barrier to gastro-œsophageal reflux.

We wish to thank Professors J. C. Goligher and A. Durward for the facilities made available by them to conduct this investigation, and to record our indebtedness to Dr. D. Taverner for his co-operation in obtaining the electromyographic recordings. We are also grateful to Miss K. Darbyshire, Mr. S. Dove, and Mr. H. Revell for their technical help, and to Mr. A. L. Pegg and Miss W. B. Walsh, of the Photographic Department, for the illustrations.

REFERENCES

ADLER, R. H., and FIRME, C. N. (1958), *Surgery*, **44**, 63.
ALLISON, P. R. (1951), *Surg. Gynec. Obstet.*, **92**, 419.
— — (1956), *Bull. Johns Hopk. Hosp.*, **99**, 182.
ATKINSON, M., EDWARDS, D. A. W., HONOUR, A. J., and ROWLANDS, E. N. (1957 a), *Lancet*, **2**, 918.
— — — — — — — — (1957 b), *Ibid.*, **2**, 1138.
— — and SUMERLING, M. D. (1959), *Gastroenterologia*, **92**, 123.
BAILLIE, M., quoted by PETERS, P. M. (1955), *Thorax*, **10**, 27.
BARRETT, N. R. (1952), *Proc. R. Soc. Med.*, **45**, 279.
— — (1954), *Brit. J. Surg.*, **42**, 231.
BOTHA, G. S. M. (1958), *Ibid.*, **45**, 569.
— — ASTLEY, R., and CARRE, I. J. (1957), *Lancet*, **1**, 659.
BRAASCH, J. W., and ELLIS, F. H., jun. (1956), *Surgery*, **39**, 901.
COLLIS, J. L., KELLY, T. D., and WILEY, A. M. (1954), *Thorax*, **9**, 175.
DORNHORST, A. C., HARRISON, K., and PIERCE, J. W. (1954), *Lancet*, **1**, 695.
FYKE, F. E., jun., CODE, C. F., and SCHLEGEL, J. F. (1956), *Gastroenterologia*, **86**, 135.
VON GUBAROFF (1886), *Arch. Anat. Physiol.*, Lpz., 395.
HIS, W. (1903), *Ibid.*, 346.
HOAG, E. W., KIRILUK, L. B., and MERENDINO, K. A. (1954), *Amer. J. Surg.*, **88**, 44.
JACKSON, C. (1922), *Laryngoscope* (St. Louis), **32**, 132.
LENDRUM, F. C. (1937), *Arch. intern. Med.*, **59**, 474.
LERCHE, W. (1950), *The Esophagus and Pharynx in Action*. Springfield, Ill.: C. C. Thomas.
MAGENDIE, F. (1813), *Memoire sur l'Œsophage*. 11 pp. Plassan.
MARCHAND, P. (1955), *Brit. J. Surg.*, **42**, 504.
NAUTA, J. (1956), *Gastroenterologia*, **86**, 219.
PETERS, P. M. (1955), *Thorax*, **10**, 27.
O'MULLANE, E. J. (1954), *Lancet*, **1**, 1209.
RIPLEY, H. R., LEARY, W. V., GRINDLAY, J. H., SEYBOLD, W. D., and CODE, C. F. (1950), *Surgical Forum*, p. 60.
WILLIS, T. (1674), *Pharmaceutice Rationalis*, Part 1. Oxford and London.
WOOLER, G. H. (1952), *Proc. R. Soc. Med.*, **45**, 290.

SHORT NOTES OF RARE OR OBSCURE CASES

TWO CASES WITH UNUSUAL CAUSES OF OBSTRUCTION OF THE COMMON BILE-DUCT

BY F. A. R. STAMMERS, C.B.E., T.D.

PROFESSOR OF SURGERY, UNIVERSITY OF BIRMINGHAM; HONORARY CONSULTING SURGEON, UNITED BIRMINGHAM HOSPITALS

Case 1.—A married woman aged 39 years was admitted under my care in June, 1952, complaining of a discharging sinus in her right hypochondrium ever since an operation at the age of 8 years for hydatid cyst of the liver. This was carried out in a private nursing-home, and was before the days of good anæsthesia or readily available blood. This was followed by a second operation a few days later, and the wound then remained healed and the patient satisfactory until the age of 21, when it broke down. A further operation was performed but the wound never healed satisfactorily; it continued to discharge a little bile continuously, and she required about three dressings daily. From time to time there was a temporary increase of discharge, and during the two years prior to the present admission there had occurred several unexpected floodings so that her dress became soaked through with bile. The condition had become a nuisance and made her feel uncertain of herself and she was forced to withdraw from social activities. Apart from this, and up to two years previously, she had felt well, but lately she suffered intermittent attacks of pain in the right hypochondrium and occasionally vomited.

The patient looked well, but in the right hypochondrium in the old subcostal scar was a sinus discharging bile profusely. Liver function tests gave normal results: hæmoglobin 13·8 g. per cent; R.B.C. 5,090,000. Cholecystogram showed no pheniodol concentration but a vague shadow that might have been a gall-stone.

A cholangiogram was performed via the fistulous tract and showed: (1) that the fistula communicated with the duct system of the right lobe of the liver; and (2) through this also with the gall-bladder and common bile-duct; (3) gross distortion of the common bile-duct within which were two translucencies, the first corresponding with the suspected stone, and the second presumably being a second translucent stone.

It was, therefore, decided to explore the duct system.

AT OPERATION.—Through a right upper paramedian incision the under surface of the liver was exposed. Adhesions were dense, but without much difficulty the gall-bladder and common duct were isolated. The latter was greatly dilated and presented a diverticulum on the right side which contained a 'stone'. A probe was passed down the fistula and the distal end seemed to be within the liver substance rather than in the bile-ducts. The common duct was opened and the 'stone' removed, but on closer inspection this proved to be a rolled-up piece of 2·5-cm. ribbon gauze, some 15 cm. in length, impregnated with bile mud. Also removed were some small, smooth, faceted pigment stones. The source of the gauze was, indeed, a puzzle. The common duct was closed around a T-tube. A small drainage tube was added to the site of operation, and the abdomen was closed. It was anticipated that, the obstruction having been removed, the biliary fistula would dry up and close spontaneously.

Following operation the patient made an excellent recovery. For the first 48 hours the fistula was dry, after which there was a slight biliary leak about every third day. A cholangiogram was performed through the T-tube on the fifth post-operative day. This showed great improvement in the shape of the common duct, there was no distortion, and it did not communicate with the fistula. Drainage into the duodenum was immediate and free. The T-tube was therefore removed.

The fistula was drying up well, and it was decided not to interfere with it. On the day prior to discharge she asked if she could have a bath, and I suggested that the sinus should be covered with some waterproof adhesive, such as Sleek. The patient interjected that she had done this in the days when the fistula had discharged a lot—in fact, she said, she used to insert ribbon gauze into the mouth of the fistula and push it down with a probe. And

so we at last knew the source of this unique obstructing agent.

A letter from her doctor in August, 1959, says that the fistula rapidly healed after her return home, and that she is in perfect health.

The second case is not unique, but extremely rare, nevertheless.

Case 2.—A woman, aged 64 years, a recognized diabetic, was admitted under Dr. Bulmer in June, 1958, because of vomiting and loss of weight. In the past five weeks she had had six attacks of what she termed 'biliousness', two in the daytime and four awakening her during the night. During the attacks she brings up a lot of wind and then vomits two or three times, but excepting whilst vomiting she suffers no pain, which may then go through to the back. The vomits are bile-stained but contain no blood. There was no dysphagia, fatty dyspepsia, or melæna. On admission she was mildly jaundiced, and although serum-bilirubin was 6·4 mg. per cent there was no pruritus. The liver was firm but regular, and 3 fingers' breadth below the costal margin. Liver function tests were normal. Cholecystography revealed a non-functioning gall-bladder, and there was gas in both the gall-bladder and biliary tree. Barium-meal studies failed to demonstrate any internal fistula. Occult blood test for the stools was positive.

A diagnosis of obstructive jaundice was made, possibly carcinoma of the ampulla, and laparotomy advised.

At Operation.—The abdomen was opened through a right paramedian incision. The liver was somewhat enlarged, with rounded edges and a somewhat pale appearance. The gall-bladder was thickened and slightly distended: so, too, was the common bile-duct. There was no evidence of inflammatory reaction in this area. Preparation was then made for cholangiography through the cystic duct. At first it was difficult to inject radiopaque fluid, as if the point of the needle had engaged in the wall of the common duct. After a little manipulation, injection was successful. The cholangiogram showed general dilatation of the biliary tree, but none had entered the duodenum. Examination of the pancreas showed the head to be rather hard; and in view of the melæna, carcinoma of the ampulla still seemed a possibility.

The gall-bladder was removed and found to contain three faceted stones. The common duct was then opened and contained about 5 ml. of bile-mud in the middle of which lay a fusiform object, about the size of a small date-stone. On closer examination this proved to be a coiled-up leaf-like object which, on unwrapping, was tough and chitinous suggestive of tomato skin. There was a *B. coli* odour. The duct was washed out by irrigation and then, because of the question of the ampulla, the second part of the duodenum was opened. Both bile and bile-mud were present in the duodenum, presumably the result of irrigation. Bougies passed freely up the duct through the ampulla, and the latter was normal in appearance.

Further palpation of the pancreas satisfied one that this was back-pressure pancreatitis, rather than neoplasia, and that the whole picture—obstruction, gas in the biliary tree, occult blood in the stools, and occasional fever—was adequately explained by the foreign body in the common duct.

The duodenum was closed and the common duct drained, and she made a satisfactory recovery.

The foreign body was proved by the pathologists to be tomato skin.

It is not uncommon to find skins and other foreign bodies in the common bile-duct following choledocho-enterostomy, but for such to gain entrance spontaneously is very rare.

METAPLASIA IN A NERVE-SHEATH SARCOMA IN VON RECKLINGHAUSEN'S DISEASE

By RICHARD A. PAYNE*

ROYAL HOSPITAL, SHEFFIELD

Chondrification in a nerve-sheath sarcoma is an "extreme rarity" (Willis, 1959). Reference has been made by Stout (1949) to osteoid tissue and cartilage in a malignant nerve-sheath tumour arising from the brachial plexus in a girl of 18 years, and a second case has been referred to by Willis (1958). This case is now reported in detail.

CASE REPORT

E. R., male, aged 31 years, was admitted to the Royal Hospital, Sheffield, in September, 1955. The patient complained of pain in the back of the right leg for two weeks. This had recurred intermittently during the previous year. His pain was throbbing and extended from the posterior aspect of the mid-thigh to mid-calf. He had paræsthesia in the foot and ankle. For two weeks the patient had been aware of a swelling on the back of the thigh.

On Examination.—The patient had neurofibromatosis with multiple cutaneous neurofibromata and pigmentation. On the posterior aspect of the right thigh, below the buttock, there was a tender firm mass deep to the deep fascia and fixed to the muscles; palpation of the mass caused tingling down the leg. Movements of the right leg were painful. The tendon-reflexes at the ankles and knees were present and equal in both limbs. There was no apparent loss of sensation.

Investigations.—A radiograph of the chest was normal. Blood examination showed a hæmoglobin of 112 per cent; white cells 9000/c.mm. The erythrocyte sedimentation rate was 5 mm. in 1 hour.

The diagnosis of a nerve-sheath sarcoma of the sciatic nerve was confirmed by a biopsy.

At Operation.—The limb was ablated on Oct. 21 by a disarticulation of the hip, performed by Mr. D. J. Robertson. The patient recovered uneventfully, but died in 1957 from pulmonary metastases.

Pathology.—The pathological aspects of the case were reported by Dr. J. L. Edwards.

Fig. 716 shows the macroscopical features of the tumour and the sciatic nerve. The tumour was approximately 9 cm. in diameter situated 5 cm. below the proximal cut end of the sciatic nerve. The mass appeared to be within an expanded nerve-sheath. In some areas this mass was inseparable from the surrounding muscles. The sciatic nerve and its branches were thickened. There were fusiform swellings in the course of the branches of the nerve.

The cut surface of the tumour showed areas of hæmorrhage and necrosis and some firm white areas.

* Now of the University Department of Surgery, the Royal Infirmary, Sheffield.

Microscopical findings: A neoplasm composed of mainly undifferentiated malignant cells—almost certainly sarcoma. However, there was differentiation to recognizable cartilage in some portions (*Figs.* 717-719). Mucin was seen in one nerve-bundle.

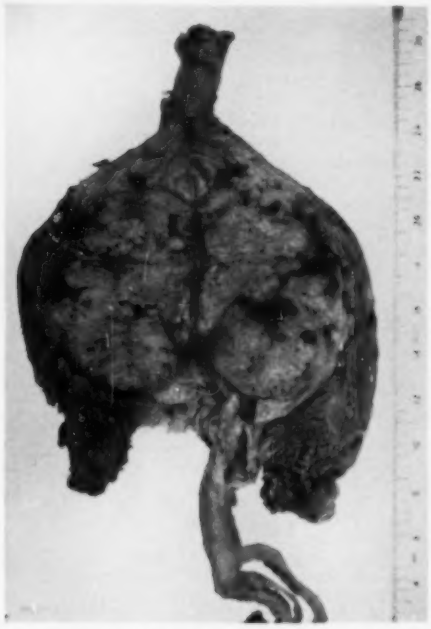


FIG. 716.—Showing nerve-sheath sarcoma from a thickened sciatic nerve. Areas of hæmorrhage and necrosis can be seen, and also some cartilage.

varieties, the neurilemmoma develops from the Schwann cells (Willis, 1958; Stout, 1935 a, b) and Stout (1946) maintains that both the neurofibroma and neurilemmoma are primarily composed of Schwannian cells. Bailey and Herriman (1938) regard neurofibromata as arising from the perineural and endoneural fibroblastic tissue. The modern concept (Willis, 1958) is to regard neurofibromas as hamartomas. A nerve-sheath sarcoma usually arises from a neurofibroma, either solitary or multiple, with other manifestations of von Recklinghausen's disease, the cell of origin, in the opinion of Stewart and Copeland (1931), being the Schwann cell. There is some doubt whether or not malignant change occurs in a neurilemmoma (Stout, 1935 a; Willis, 1953).

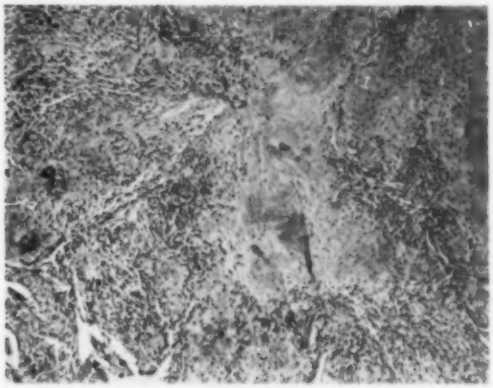


FIG. 717.—Showing cartilage among fusiform cells. (× 45.)

FIG. 718.—Showing areas of cartilage in varying stages of development and fusiform cells. (× 64.)

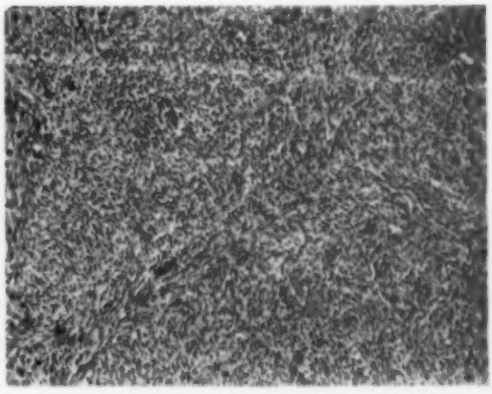


FIG. 719.—Cellular area of nerve-sheath sarcoma with possibly a few cartilage cells. (× 64.)

DISCUSSION

According to Stout (1949), the origin of his case of a nerve-sheath sarcoma, showing osteoid tissue and cartilage, was from the Schwann cells.

There are conflicting ideas on the histogenesis of peripheral nerve-sheath tumours. Of the benign

If the tumours are regarded as being derived from the Schwann cells, it affords an explanation for the presence of cartilage. The Schwann cells are epidermal and are derived from the neural crests which in lower vertebrates give rise to the branchial cartilages. Willis (1958) has remarked

that in neither Stout's case nor the present one can origin from the Schwann cells be observed; histologically the reported case could be a fibrosarcoma without Schwann-cell origin. This is not an uncommon appearance in a nerve-sheath sarcoma which infrequently shows features characteristic of Schwann cells, although these cells are sometimes found in neurofibromata.

Among the other factors associated with metaplasia is the presence of mucin, frequently found in nerve-sheath sarcomas; mucin stimulates connective tissue to form cartilage. Bone is sometimes seen in old wounds, hæmatomas, and inflammatory lesions resulting from osteoblastic activity by fibroblasts from the stimulation of calcium salts and cellular debris. These factors are unlikely to be significant in the present case.

The clinical aspects of nerve-sheath sarcoma have been dealt with in many reviews, for example, Cutler and Gross (1936), Herrmann (1950), Speed (1942), Stewart and Copeland (1931). It has been estimated that from 8 to 15 per cent of neurofibromata become malignant (Speed, 1942). Hosoi (1931) quotes an incidence of 13 per cent in his series. Malignant change is to be suspected if the tumour becomes painful, enlarges rapidly, and is associated with paralysis and anæsthesia. Incomplete excision of a neurofibroma is liable to be followed by local recurrence and malignant degeneration (Speed, 1942). The nerve-sheath sarcoma tends to recur and finally gives rise to distant metastases, usually pulmonary, in 20 per cent of patients (Hosoi, 1931).

Treatment.—In general, neurogenic sarcomas are neither more nor less malignant than the majority of the fibrosarcoma group (Cade, 1951). In Cade's opinion the best results of treatment of the group are from a combination of local excision and radiotherapy, amputation being recommended for the cases where the size or site of the tumour makes local removal undesirable or the patient is left with a useless limb. Writing in the past Geschickter (1935), Speed (1942), and Cutler and Gross (1936) were among those authorities who recommended amputation as the primary treatment of a nerve-sheath sarcoma. Local excision in the present case would have left the patient with a useless limb.

SUMMARY

The clinical features and pathology of a nerve-sheath sarcoma showing chondrification are described.

Factors and clinical aspects in this example of metaplasia are discussed.

Acknowledgements.—I wish to thank Mr. D. J. Robertson for permission to report the case; Dr. J. L. Edwards for the account of the pathology; Mr. D. Bradey for cutting the sections.

REFERENCES

BAILEY, P., and HERRMANN, J. D. (1938), *Amer. J. Path.*, **14**, 1.
CADE, Sir STANFORD (1951), *Proc. R. Soc. Med.*, **44**, 19.
CUTLER, E. C., and GROSS, R. E. (1936), *Arch. Surg., Chicago*, **33**, 733.
GESCHICKTER, C. F. (1935), *Amer. J. Cancer*, **25**, 377.
HERRMANN, J. (1950), *Ann. Surg.*, **131**, 206.
HOSOI, K. (1931), *Arch. Surg., Chicago*, **22**, 258.
SPEED, K. (1942), *Ann. Surg.*, **116**, 81.
STEWART, F. W., and COPELAND, M. M. (1931), *Amer. J. Cancer*, **15**, 1235.
STOUT, A. P. (1935 a), *Ibid.*, **24**, 751.
— — (1935 b), *Ibid.*, **25**, 1.
— — (1946), *Clin. Proc.*, **5**, 1.
— — (1949), *Atlas of Tumor Pathology: Tumors of Peripheral Nervous System*. Washington, D.C.: Armed Forces Institute of Pathology.
WILLIS, R. A. (1953), *Pathology of Tumours*, 2nd ed. London: Butterworth & Co.
— — (1958), *The Borderland of Embryology and Pathology*. London: Butterworth & Co.
— — (1959), in *Modern Trends in Pathology* (ed. Collins). London: Butterworth & Co.

JEJUNAL DIVERTICULOSIS AS A CAUSE OF INTESTINAL OBSTRUCTION

BY W. B. N. BOMFORD, THE LONDON HOSPITAL

INTESTINAL obstruction remains one of the commonest surgical emergencies and jejunal diverticulosis one of the rarest of causes found in laparotomy.

In 5448 autopsies performed at the Bernhard Baron Institute of Pathology, London Hospital, from 1940 to 1958, multiple diverticula of the jejunum were found in 3 cases. Diverticula in fewer numbers, 1 to 12, were recorded in 18 further examinations, but in none of these cases was there any record of complications affecting the diverticula, nor were any concretions noted. Milnes Walker (1945) reported 1 case of concretion formation and found 4 others in the literature, but while 4 of these 5 cases had intestinal obstruction, in a series of 205 cases of small-bowel obstruction discussed by Bollinger and Fowler (1953), no case due to jejunal diverticulosis was found.

The case described here is one of intestinal obstruction by a concretion which is believed to have been expelled from a diverticulum near the duodenojejunal flexure, in a patient suffering from diverticulosis of the jejunum.

CASE REPORT

Mrs. F. C., aged 48 years, was transferred from a nearby mental hospital complaining of abdominal pain with vomiting for the past three days. This patient had "for some time" suffered from attacks of abdominal pain which usually passed with rest and the warmth of a hot-water bottle. There was no vomiting during the attacks, and alkalis were administered to relieve the symptoms, which were interpreted as indigestion. Three days before admission she experienced the onset of central abdominal pain with vomiting; the bowels had not acted since the onset of pain, although previously they had been regular. During the early part of the attack she had been given two doses of white medicine believed to be alkali mixture.

ON EXAMINATION.—She was a co-operative, thin, rather flushed woman with a moist furred tongue. The

abdomen was tender in the central region, but no distension was noted. Rectal examination: a few flecks of fæces were present, but no mass or tenderness. B.P. 95/60.

A provisional diagnosis of small-gut obstruction was made, which was confirmed by gastric aspiration of offensive yellow fluid and a plain radiograph of the abdomen revealing small-gut distension. Exploratory laparotomy was carried out through a right lower paramedian incision. The findings were as follows: Distended loops of small intestine presented, which were traced down until the cause of the obstruction was found. This proved to be a mass of white inspissated material about 1½ in. in diameter impacted in the lumen of the ileum. The mass of what was thought to be alkali powder was crushed between the fingers and washed down with small-gut contents held up above. As the gut was being replaced, a diverticulum was seen which proved to be on the mesenteric side of the jejunum; numerous other diverticula were soon apparent and were noted to be confined to the obstructed portion of the gut. Some secondary volvulus of the distended small intestine had occurred and this was reduced. Closer inspection revealed that the diverticula were pink, lobulated, thin-walled, easily compressible swellings, and the tip of the little finger invaginating the pouch could fill the wide orifice leading into the lumen of the jejunum.

The patient made an uninterrupted recovery from the operation, with a natural bowel action on the fifth post-operative day.

RADIOLOGICAL INVESTIGATION.—When the patient was fully recovered from her operation, a follow-through barium meal was carried out, in an attempt to demonstrate the diverticula (*Figs.* 720, 721).

One large diverticulum in the region of the duodenojejunal flexure is demonstrated (*Fig.* 720) and several smaller fluid levels, marked by arrows, indicate the presence of multiple diverticula (*Fig.* 721). The size of the concretion suggested that it had arisen in the largest and uppermost diverticulum, which is shown in *Fig.* 720. It had become arrested in the lower ileum at the site usually associated with obstructing gall-stones. The diverticula are often difficult to fill with barium and even when filled may be obscured by barium in the lumen of the jejunum.

FIG. 720.—Opaque meal showing large diverticulum near the duodenojejunal flexure, the probable site of formation of the concretion.

FIG. 721.—Radiograph showing several diverticula containing barium.

DISCUSSION

Phillips (1952), describing 2 cases where dilated, hypertrophied bowel was found without organic obstruction, stated that he regarded some degree of intestinal obstruction as an intrinsic part of jejunal diverticulosis, rather than a complication arising *de novo*; he considered the symptoms usually classified as dyspepsia to be a form of chronic intestinal obstruction. Benson, Dixon, and Waugh (1943), in a series of 122 cases, reported that non-organic, chronic, small-bowel obstruction was the commonest complication in jejunal diverticulosis, and, having found one solitary diverticulum in a hypertrophied obstructed loop, they questioned whether the diverticula might not be the result rather than the cause of obstruction.

Slater (1953) described the case of a woman who had taken alkalis for two weeks of dyspepsia and was then admitted with a tentative diagnosis of intestinal obstruction following gall-stone colic. Laparotomy revealed a concretion impacted in the lumen of the gut 5 ft. below the duodenojejunal flexure, with

diverticula in 2 ft. of the jejunum. He compared intestinal obstruction due to concretions in the lumen, gall-stone, aggregations of fruit skins, and concretion from diverticula and bowel loculated by stricture. His case appears to be very similar to the one described here, with the exception that removal of the concretion was performed and fragmentation not attempted. Milnes Walker (1945) stressed the fact that concretions in jejunal diverticula do not cause diverticulitis, but do cause intestinal obstruction. A concretion causing obstruction by blocking the lumen of the jejunum was reported by Terry and Mugler (1921), who relieved the condition by breaking up the mass, the fragments being passed per rectum. Other examples have been reported by Watson (1924), who described a concretion the size of a walnut in a jejunal diverticulum causing obstruction by encroachment on the lumen, and Christ (1932), who found obstruction by a concretion displaced into the lumen. Fraser (1933), in his classical paper, described one case of obstruction caused by angulation of the gut by perforation of a peridiverticular abscess. Hubeny and Pollack (1938) report obstruction from adhesions to jejunal diverticula. Armitage, Fowweather, and Johnstone (1950) reported a case where intermittent obstruction had been occurring; at operation an enterolith was found in the lower ileum and a second one in a duodenal diverticulum. Analysis showed 90 per cent bile acid and 0·4 per cent mineral, which explained why concretions are not opaque to X rays.

Martin, Grotzinger, and Bower (1954) divided obstruction into two types: (1) Acute, which may be due to enteroliths formed within diverticula, pressure from inflammatory mass associated with diverticulitis, volvulus, stricture from adhesions, and pressure of filled diverticula on intestines; (2) Chronic, without mechanical obstruction from stricture or adhesions. Braithwaite (1923) found that symptoms such as pain, nausea, and flatulence with some distension and vomiting could be caused by traction on the duodenojejunal flexure of a distended loop of small bowel containing diverticula. Boling (1930) described a patient where obstruction resulted from impaction or incarceration of most of the small intestine in the pelvis, the gut containing 250 to 350 diverticula.

Treatment.—When an acute complication such as intestinal obstruction arises in a patient with jejunal diverticulosis, surgical treatment is often indicated. Benson and others (1943) advise that the initial operative measures should be limited to relief of obstruction as the patients are often frail and present as poor operative risks. They advise a short-circuit operation rather than resection of the obstructed portion of bowel. Phillips (1952) reported a case where a by-pass operation relieved the symptoms of recurrent diverticulosis, while Braithwaite (1923) performed a short-circuit without benefit, relief of symptoms eventually following resection some months later.

In cases where a concretion is found impacted in the lumen of the ileum, the obstruction may be relieved by removal of the mass through an incision in the wall of the gut (Slater, 1953). The obstruction in the patient reported here was relieved by fragmentation of the mass impacted in the lumen of the bowel, a similar instance having been recorded by Terry and Mugler (1921), who were able to crush the obstructing concretion and leave it to the fluid intestinal contents, held up above, to wash down the fragments.

When a diverticulum is found with a concretion in situ, excision is advised (Milnes Walker, 1945; Renard and Bergeret, 1921).

The problem of the multiple diverticula remains, for while resection of a portion of the bowel has been shown to relieve persistent flatulent dyspepsia (Edwards, 1936), and steatorrhœa with megaloblastic anæmia (Watkinson, Feather, Marson, and Dossett, 1959), hypertrophy of diverticula in the remaining loops of small intestine may occur (Gerster, 1938, quoting a case of Godard, Bourdial, and Zourekatis).

Removal of a loop of jejunum containing diverticula may relieve chronic intestinal obstruction and is indicated in recurrent attacks of diverticulitis. But excision of several feet of jejunum, in an effort to clear the gut of all diverticula, does not appear to be justifiable, in view of the natural history of the disease, and the importance of the jejunum in the process of digestion and absorption.

REFERENCES

ARMITAGE, G., FOWWEATHER, F. S., and JOHNSTONE, A. S. (1950), *Brit. J. Surg.*, **38**, 21.

BENSON, R. E., DIXON, C. F., and WAUGH, J. M. (1943), *Ann. Surg.*, **118**, 377.

BOLING, J. R. (1930), *J. Amer. Med. Ass.*, **95**, 267.

BOLLINGER, J. A., and FOWLER, E. F. (1953), *Arch. Surg. Chicago*, **66**, 888.

BRAITHWAITE, L. R. (1923), *Brit. J. Surg.*, **11**, 184.

CHRIST, A. (1932), *Dtsch. Z. Chir.*, **236**, 560.

EDWARDS, H. C. (1936), *Ann. Surg.*, **103**, 230.

FRASER, I. (1933), *Brit. J. Surg.*, **21**, 183.

GERSTER, J. C. A. (1938), *Ann. Surg.*, **107**, 753.

HUBENY, M. J., and POLLACK, SIMON (1938), *Amer. J. Roentg.*, **40**, 689.

MARTIN, W. L., GROTZINGER, P. J., and BOWER, R. (1954), *Arch. Surg. Chicago*, **69**, 711.

PHILLIPS, J. C. H. (1952), *Brit. J. Surg.*, **40**, 350.

RENARD, M., and BERGERET (1921), *Bull. Soc. Anat. Paris*, **18**, 220.

SLATER, N. S. (1953), *Brit. J. Surg.*, **41**, 60.

TERRY, W. I., and MUGLER, F. R. (1921), *Arch. Surg. Chicago*, **2**, 347.

WALKER, R. MILNES (1945), *Brit. J. Surg.*, **32**, 457.

WATSON, C. M. (1924), *Surg. Gynec. Obstet.*, **38**, 67.

WATKINSON, G., FEATHER, D. B., MARSON, F. G. W., and DOSSETT, J. A. (1959), *Brit. med. J.*, **2**, 58.

REVIEWS AND NOTICES OF BOOKS

Bibliography of Cancer produced by Pure Chemical Compounds. A survey of the literature up to and including 1947. By OTTO NEUBAUER, M.D. 9 × 6 in. Pp. 604 + xxviii. 1959. London: Oxford University Press. 42s.

THIS may be said to be the work of a lifetime because it took Professor Neubauer nearly twenty years to complete this present volume and then he did not finish his task, for he died in November, 1959, and Miss Phyllis Coombs, of the Chester Beatty Research Institute, finished the volume.

The work throughout was supported by the British Empire Cancer Campaign, which also made a contribution to the cost of production.

This important work will prove of enormous benefit to all cancer research workers both at home and overseas.

As a reference volume it is invaluable.

I Diverticoli dell'Esofago. By GIULIO R. BETTOLO and GUIDO FRANZINI. $9\frac{3}{8} \times 6\frac{7}{16}$ in. Pp. 203, with 60 illustrations. 1959. Milan: Unione Tipografica.

ŒSOPHAGEAL diverticula have been recognized as an autopsy finding at least since the mid-eighteenth century, but diagnosis and treatment in the living are affairs largely of the last fifty years; indeed, in respect of those situated in the intrathoracic portion, treatment has been widely practised only in the last twenty years. The present time is therefore opportune for the appearance of the present work which is up to date, comprehensive, and authoritative. The outlook is thoroughly international and full acknowledgement is given to early British contributors including Ludlow, of Bristol, who is credited with the first description of a pharyngo-œsophageal diverticulum (in a letter to William Hunter, dated 1764), and Charles Bell, who gave a further description in 1816. More recent British works, such as those of Dunhill, Negus, and others on the pharyngo-œsophageal, and Barrett on the intrathoracic varieties, are also given due prominence, while American, French, German, and Italian works are freely drawn upon. The personal experience of the authors comprises 124 cases (59 pharyngo-œsophageal, 37 parabronchial, and 28 epiphrenic), treated partly in Professor Santy's clinic in Lyons and partly in Milan. The history, classification, aetiology, pathological anatomy, clinical features, and treatment are fully dealt with in turn, and the authors' personal cases are tabulated in respect of age, site, size, symptoms, complications, treatment, and results. The bibliography, containing nearly 500 references, is well set out and free from all but the most trivial typographical errors. It has the advantage of including also the titles of the papers listed. The radiographs and figures are all of the highest standard and the format of the book is worthy of the excellence of the contents.

Hermaphroditism, Genital Anomalies and Related Endocrine Disorders. By HOWARD W. JONES, jun., M.D., Associate Professor of Gynecology, Johns Hopkins University School of Medicine; and WILLIAM WALLACE SCOTT, M.D., Ph.D., Professor of Urology, Johns Hopkins University School of Medicine. $10\frac{1}{2} \times 7\frac{1}{4}$ in. Pp. 456 + xvi, with 466 illustrations. 1958. Baltimore: Williams & Wilkins Co. (London: Baillière, Tindall & Cox Ltd.). 128s.

SINCE Hugh Young produced his classic work on genital abnormalities in 1937 there have been great advances in the study of intersexuality, nuclear sexing, and disorders of the adrenal glands. This book, which is the natural successor of Young's and includes many of his illustrations, covers the current knowledge of the whole subject in a manner suitable for the expert. It is an essential for urologists, gynæcologists, and all interested in hormonal surgery.

A Short Practice of Surgery. Eleventh edition. By HAMILTON BAILEY, F.R.C.S. (Eng.), F.A.C.S., F.I.C.S., F.R.S.E., and MCNEILL LOVE, M.S. (Lond.), F.R.C.S. (Eng.), F.A.C.S., F.I.C.S. With chapters by JOHN CHARNLEY, F.R.C.S. (Eng.), WILLIAM CLELAND, M.R.C.P. (Lond.), F.R.C.S. (Eng.), and GEOFFREY KNIGHT, F.R.C.S. (Eng.). $9\frac{1}{2} \times 6\frac{1}{2}$ in. Pp. 1389 + xii, with 1697 illustrations, 285 in colour. 1959. London: H. K. Lewis & Co. Ltd. £4 4s.

THIS is one of the few students' text-books of surgery complete in one volume. True it is a big volume, but surgery is a big subject. Whilst the two original authors remain responsible for most of the text they have called in experts to write on orthopædics, thoracic surgery, neurosurgery, and radiotherapy, and the whole work has been kept up to date. It is possible to find some omissions; for example there is no mention of the most effective exposure of the kidney through the bed of the excised 12th rib, but there are few points which will not find general agreement amongst practising and teaching surgeons. The views expressed are sufficiently dogmatic for the student who has yet to qualify; the range of cover is sufficiently great for most of the higher surgical examinations, and the text is easy to read and very well illustrated. As a test we compared a recent finals paper in surgery with the information given here and found every question adequately answered. "Bailey and Love" has rightly achieved great popularity and in this eleventh edition it will retain it. The price is moderate for a book of this size with so many excellent illustrations, many in colour.

Prophylaxie et Traitement des Escarres de Decubitus. By R. VILAIN. 9 × 7 in. Pp. 120, with 60 illustrations. 1960. Paris: L'Expansion Scientifique Française. N.F.13.50.

IN far too many hospitals in this country the prevention of pressure sores is regarded by the ward sister as her own private preserve and her own preventive and therapeutic measures are jealously guarded secrets. Any inquiry about the patients' 'backs' is liable to be met with such withering silence that the unfortunate houseman will never dare to repeat his question. Since he has been taught little, if anything, about nursing care in his student days, he may dismiss the problem of pressure sores from his mind for the rest of his life. This short monograph by Raymond Vilain is a masterpiece and should shatter any such complacency. He describes in detail the pathogenesis of decubitus ulcers and in a few delightful paragraphs discusses and dismisses many of the common theories of their origin, such as local heat, bread-crumbs, residue of caustic soda in badly rinsed bed linen, rough sheets, and infection. The rubber ring and the water bed are roundly condemned along with two rather strange preventive measures which are still, it seems, used in parts of France—placing a piece of chamois leather between the patient and the bed and placing the skin peeled from half an orange beneath the heels of the patient!

The early warning signs are clearly described and illustrated and the author discusses the preventive measures which have been so highly and successfully developed by the nurses and physiotherapists at the Hôpital Bichat in Paris. As for the treatment of the

established ulcer, the author indicates the most suitable types of local dressing and discusses critically the solutions and preparations he has found simplest and best. He strongly deprecates the 'polypharmaceutical approach' in the local treatment of these lesions.

For those ulcers which require more drastic measures, the principles of surgical excision are clearly indicated and the various methods of closing the defect whether by suture, free skin graft, or local pedicled flap.

This little volume is an example of the surgical monograph at its best. Its scientific content is matched by a literary style of such outstanding brilliance that even the best translation into English would be sacrilege.

Zum Krankheitsbild des Sogenannten Cardiospasmus. By P. C. ALNOR. 9 × 5¾ in. Pp. 78 + viii, with 33 illustrations. Volume 9 of Medizin Theorie und Klinik in Einzeldarstellungen 1959. Heidelberg: Alfred Hüthig Verlag. D.M.11.80.

THE cause of 'cardiospasm' still remains to be elucidated, nearly 300 years since the condition was first described.

Nothing new emerges from this study. Hurst's concept of achalasia of the cardia, which dates back to 1914, is again preferred—yet the misnomer by which this condition is known still survives and even flourishes—and is believed to be acquired by ischæmic damage to the myenteric plexus just proximal to the cardia. We are left to guess what it is that produces the ischæmia: if achalasia of the cardia is commoner in women and does usually arise between the second and fourth decades, could not the transient reflux-œsophagitis common in pregnancy be incriminated?

With regard to therapy, again no new ground is broken. Psychotherapy and spasmolytic drugs are dismissed as ineffective. Bouginage and Heller's operation still appear to be the main stand-by, and, if they do not preclude recurrence of the achalasia, at least they seem to spare the patient the complication of reflux-œsophagitis after œsophago-gastrostomy and other procedures.

This contribution has been published as the ninth volume in a series of monographs embodying reviews of the world literature and recording original research. Presented in this guise, Dr. Alnor's re-appraisal of the subject disappoints by being too pretentious.

The Human Spine in Health and Disease. By GEORG SCHMORL, M.D., and HERBERT JUNGHANNS, M.D. 11 × 7¼ in. Pp. 285 + xii, with 419 illustrations. 1959. New York and London: Grune and Stratton. $21.00.

ALTHOUGH the first edition of this monograph appeared in Germany in 1932, and since that date there have been three subsequent German editions, yet this is the first edition in English. Dr. Wilk and his co-translator, Dr. Goin, have carried out their task in an excellent fashion.

This monograph is acknowledged to be the best and most authoritative book on the spinal column. The vast amount of material studied by the authors and the excellence of the illustrations will make this volume a popular one on both sides of the Atlantic.

The anatomy and physiology of the human spine is meticulously described, and every known congenital anomaly is depicted and portrayed. Morphological variations are explained in detail. Perhaps the best part of this volume is that devoted to the many pathological conditions met with in the spine.

The large section dealing with the normal and abnormal conditions of the intervertebral disks is truly excellent. The bibliography is immense, but, as one would expect, almost entirely devoted to German literature.

This book will now become the reference volume on all conditions of the spinal column.

Tools of Biological Research. Edited by HEDLEY J. B. ATKINS, D.M., M.Ch. (Oxford), F.R.C.S. (Eng.), Hon. F.A.C.S., Director, Department of Surgery, Guy's Hospital, London. 8¾ × 5½ in. Pp. 183 + xvi, illustrated. 1959. Oxford: Blackwell Scientific Publications Ltd. 37s. 6d.

THIS book contains the introductory address by Sir Cyril Hinshelwood and the ten papers read at a Symposium dealing with modern methods of surgical research. Amongst those who heard the papers were many who felt the need to read them. Mr. Hedley Atkins has now redeemed his promise and has produced this well-edited and amply illustrated account of the proceedings. Those who did not hear them will be able to make up for their loss by reading them here.

Each account is written by an expert in one particular field; it must succeed in its object of informing workers in other fields of the possibilities of methods and tools other than their own. The pure clinician, even if not always in favour of randomized experiments, will have a better understanding of the interpretation of the tests he orders if he knows something of the techniques used in carrying them out. Research workers in their turn must be gratified to know of the wide interest aroused by this publication. Mr. Hedley Atkins has rendered a great service to surgery.

The Biochemical Response to Injury. A symposium organized by the Council for International Organizations of Medical Sciences. Edited by H. B. STONER. 8¾ × 5½ in. Pp. 467 + xii, illustrated. 1960. Oxford: Blackwell Scientific Publications. 57s. 6d.

IN 1958 an international symposium on the biochemical effects of injury was held in Australia under the aegis of the Council for International Organizations of Medical Sciences immediately following the Fourth International Congress of Biochemistry. This volume consists of the papers delivered at that symposium under the general editorship of Dr. H. B. Stoner, of the Medical Research Council.

The papers cover a wide range and deal with the effects of mild stimuli as well as those of grave injury. They treat of local and general effects both over short periods of time and throughout the whole period of response up to the time of recovery. Some papers deal with vital reactions, others with the pathological changes observed at post-mortem. Much attention is paid to circulatory effects and the dilatation of capillaries with its consequences which are of paramount importance in the response of the body to injury.

To surgeons who have been unable to follow recent trends in the basic concepts of response to injury, it is interesting to note that in the paper on the effects of injury on the adrenal glands by Pekkarinen, of Finland, Selye's work is quoted perfunctorily in the first paragraph and thereafter throughout a long paper there is no mention of his name. In his introduction, too, D. P. Cuthbertson argues that Selye's concept has outstripped the experimental evidence and "by its very over-simplification has tended to inhibit further work". Selye, we gather, is 'non-U'.

No difficulty was found in defining the term 'shock'. This was accepted as being that state into which an animal passed after injury, as distinct from 'inflammation', which was the local response to injury. There was some trouble, however, in defining the word 'injury' and difficulties arose in regard to bacterial and pathological injuries together with physiological stress. On the whole, however, the participants in the symposium appeared to understand each other well enough without being hindered by too rigorous definitions.

The Editor himself, together with C. J. Threlfall, has written a most informative paper on the effect of limb-ischæmia on carbohydrate metabolism and energy systems,

and Dr. D. P. Cuthbertson deals with the important problem of protein metabolism following physical injury. All the eighteen papers are well argued and are a mine of information on present views on the biochemical effects of injury. The publication is meticulous and this is a book that deserves a place in every library catering for those interested in the academic aspects of the consequences of trauma.

Actualités de Chirurgie Orthopédique et Reparatrice. A series of lectures and discussions given at the Cochin Hospital, Paris. Edited by MERLE D'AUBIGNÉ. 10¾ × 8¼ in. Pp. 86, fully illustrated. 1959. Paris: L'Expansion Scientifique Française. N.F.8.70.

FOUR or five times each year, symposia are held in the Orthopædic Clinic of Professor Merle D'Aubigné at the Hôpital Cochin in Paris, each introduced by some three or four experts on the subject which is then thrown open for general discussion. This slim volume deals with three of these symposia held during the years 1958 and 1959 and all concerned with traumatology.

The first deals with compound fractures of the leg with important contributions from Merle D'Aubigné, Gosset, and Vilain from Paris, Trillat from Lyon, Decoulx from Lille, and Michon from Nancy. All agree on the importance of skin cover, but opinion is divided on the merits of internal fixation as opposed to simple plaster fixation at the primary operation.

The second deals with fractures of both bones of the forearm. Mervyn Evans was invited to defend the closed method of treatment of these fractures. Merle D'Aubigné discusses open reduction and stresses the value of compression plating using the 'co-apteur' of Professor Danis. Professor Sorrel, from the Hôpital Trousseau, reviews the late results in adult life of these fractures sustained in infancy, and his contribution is outstanding.

The third deals with fractures and dislocations of the cervical spine. This reviews the problems as seen by the orthopædic surgeon (Ramadier and Perraguin), the neurosurgeon (Pertuiset), the urological surgeon (Bitker), and the physician at the rehabilitation centre (Maury). All of these contributions are beautifully presented and well illustrated.

The whole volume is a delight to read and we look forward to further publications of this type.

The Cell of Schwann. By GILBERT CAUSEY, M.B., F.R.C.S., Professor of Anatomy, Royal College of Surgeons of England. 8¼ × 5¼ in. Pp. 120 + xii, with 40 illustrations. 1960. Edinburgh and London: E. & S. Livingstone Ltd. 21s.

ALTHOUGH Professor Sir Roy Cameron contributed a large volume of over eight hundred pages in 1952 devoted to the pathology of the cell, yet it must be very uncommon for anyone to devote a monograph to a particular cell. But Professor Causey has just performed this very task, for he has written an excellent and stimulating book on the cell of Schwann, and what is more, has pointed out how important this cell is.

The morphology of the neurilemmal cell or cell of Schwann is in many ways unique, and Professor Causey tells us all about these interesting features. The photomicrographs taken by means of the electron microscope demonstrate small nerve-fibres in the cytoplasm of active Schwann cells. Neoplasms may occur in Schwann cells both in animals and in man, and these are discussed under the title of 'Schwannoma'.

Sir James Paterson Ross writes a foreword in which he says that he considers that Professor Causey's book is a gratifying contribution to science and a stimulus to further research.

This monograph is outstanding, and it is beautifully produced and its cost is most moderate.

British Medical Bulletin. Volume 16, Number 1, January 1960. Antibiotics in Medicine. 11 × 8½ in. Pp. 88, illustrated. Published by the Medical Department, The British Council. 20s.

THE accelerating rate of discovery of new and specific remedies in medicine is to some extent a self-generating process. As a new line of investigation is opened up, it paves the way for yet other approaches. Inevitably such progress raises fresh problems in its train. Perhaps no development in medicine has been at once so rapid and so complex as that of antibiotics. The *British Medical Bulletin* in its issue "Antibiotics in Medicine" performs a function of peculiar importance for the physician and surgeon in his struggle to keep up to date, not only in general principles but also in details of practice. The subjects in this issue of the *Bulletin* range from general matters, from the mode of discovery of antibiotics and their chemical nature and relationships, to the methods of their employment, their behaviour in the body and the ill-effects as well as benefits they can produce. Acquired bacterial resistance is discussed in the light of our most recent knowledge. The problem of combinations of antibiotics in different infections is discussed. There are contributions concerned with specific clinical use, among them being the preventive administration of antibiotics in medicine and surgery. The *Bulletin* has achieved remarkable success in its aim to present the reader with well-ascertained information on antibiotics, ranging from the scientific basis of the subject to their practical use in patients. No physician or surgeon could fail after reading this *Bulletin* to make sounder judgements in this ever-changing and all-important field.

British Surgical Practice, Surgical Progress 1959. Edited by Sir ERNEST ROCK CARLING, LL.D., F.R.C.S., F.R.C.P., F.F.R., Honorary Consulting Surgeon, The Westminster Hospital; and Sir JAMES PATERSON ROSS, K.C.V.O., LL.D., M.S., F.R.C.S.(Eng.), F.R.C.S. (Ed.), F.R.A.C.S., F.A.C.S., F.F.R., Surgeon, St. Bartholomew's Hospital, London. 9¾ × 6¼ in. Pp. 391 + x, with 90 pp. Index and 93 illustrations. 1959. London: Butterworth. 52s. 6d.

IN the production of this volume Sir Ernest Rock Carling and Sir James Paterson Ross perform once again their annual service to British Surgery, and to British Surgeons —indeed, to all surgeons conversant with the English language. The volume is the ninth in the series of yearly supplements to *British Surgical Practice* since publication of the latter was completed.

This current issue in every way maintains the standard of editorship which surgeons have now come to accept as a matter of course from these two scholarly contemporaries. One particularly admires their imaginative choice of subjects, and their selection of authors. It would be invidious to single out any one of the articles from its fellows on the basis of merit alone, and as the articles cover aspects of recent thought and work in almost every branch of surgery, their appeal will naturally vary according to the main interests of the reader. Some of them are indeed of very general interest. It is particularly felicitous to have brought into the limelight the very important, but oft neglected and perhaps, to the young surgeon unglamorous, work of Casualty, though perhaps it may have been even more felicitous if the editors had thought of giving the article on the subject by Maurice Ellis pride of place, instead of putting it last!

All who are interested in problems of the gastro-intestinal tract—which means all so-called 'general' surgeons—will find special reasons for welcoming the book, if only for the comprehensive article on peptic ulcer prepared by Dr. Wilfred Card and Professor John Bruce, whose co-operation in the practice of gastroenterology is a well-known and much appreciated feature

of the Edinburgh School. But this is only one item amongst a feast of good things—Gillis and Kelham on Amputations; Patey on the Parotid; Goligher on Rectal Surgery; Ormerod and McLay on the New Plastic Operations for Deafness; the Hadfields (pére et fils) and Welbourn on Breast Cancer; Rycroft on Corneal Grafts; to mention but a few.

Short abstracts of relevant current works follow most of the articles, and the admirable noter-up (what an ugly, yet meaningful expression!) follows the index. The format follows the usual pattern, and is beyond criticism.

The cliché 'no surgeon can afford to be without, etc.' seems to be more applicable to this series than to any other in the whole range of surgery. For the hopeful, struggling, prospective F.R.C.S.; for the mature surgeon actively engaged in practice, and perhaps too busy for literary research, or out of convenient reach of a medical library; for the professor preparing for his lectures—all grades will find possession of them an invaluable asset.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.*]

A Symposium on *p*H and Blood Gas Measurement. Edited by RONALD F. WOOLMER, V.R.D., B.A., B.M., F.F.A.R.C.S., Professor of Anæsthetics in the Royal College of Surgeons of England. 8½ × 5½ in. Pp. 210 + viii, illustrated. 1959. London: J. & A. Churchill Ltd. 30s.

Treatment of Urinary Lithiasis. Compiled and edited by ARTHUR J. BUTT, B.S., M.D., F.A.C.S., Baptist Hospital, Pensacola, Florida. 10 × 7 in. Pp. 577 + xxii, fully illustrated. 1960. Springfield, Illinois: Charles C. Thomas. (Oxford: Blackwell Scientific Publications Ltd.) £8 8s.

Cardiac Resuscitation. Edited by J. WILLIS HURST, M.D. 9 × 5½ in. Pp. 141 + x, illustrated. 1960. Springfield, Illinois: Charles C. Thomas. (Oxford: Blackwell Scientific Publications.) 44s.

Peptic Ulceration. By CHARLES WELLS, Professor of Surgery, University of Liverpool; and JAMES KYLE, M.B., M.Ch., F.R.C.S., F.R.C.S.(I.), Senior Lecturer in Surgery, University of Aberdeen. 9½ × 6½ in. Pp. 260 + xii, with 44 illustrations. 1960. Edinburgh and London: E. & S. Livingstone Ltd. 42s.

Body Fluids in Surgery. By A. W. WILKINSON, Ch.M., F.R.C.S.E., F.R.C.S., Nuffield Professor of Pædiatric Surgery, The Institute of Child Health of the University of London. Second edition. 8½ × 5½ in. Pp. 276 + xii, with 12 illustrations. 1960. Edinburgh and London: E. & S. Livingstone Ltd. 21s.

Pathogenesis and Treatment of Occlusive Arterial Disease. The Proceedings of a Conference held in London at the Royal College of Physicians of London, Nov. 13–14, 1959. Edited by LAWSON MCDONALD. 9 × 5¾ in. Pp. 237 + xii, illustrated. 1960. London: Pitman Medical Publishing Co. 25s.

Les Infections Fistulisantes de l'Anus et Leurs Séquelles. By G. CABANIÉ. 10 × 6½ in. Pp. 212, with 114 illustrations. 1960. Paris: Masson et Cie. N.F.39.00.

Chirurgie du Côlon. By HENRI WELTI. 9½ × 6 in. Pp. 386, with 114 illustrations. 1960. Paris: Masson et Cie. N.F.60.00.

Anglo-American Conference on Proctology. Held at The Royal Society of Medicine, June 29–July 1, 1959. A Supplement to the *Proceedings of the Royal Society of Medicine*. Volume 52. 9¾ × 7 in. Pp. 129, fully illustrated. 1959. London: The Royal Society of Medicine. 21s.

Praktische Operationskunde und Instrumentenlehre. By HARRO SEYFARTH and ELLY JAEGER. 9½ × 6½ in. Pp. 464 + xx, with 214 illustrations. 1960. Jena: Gustav Fischer. D.M.36.70.

Essays on the First Hundred Years of Anæsthesia. Volume I. By W. STANLEY SYKES, M.B.E., M.B., B.Chir.(Cantab.), D.A. 8¾ × 6½ in. Pp. 171, with 19 figures and 39 plates. 1960. Edinburgh and London: E. & S. Livingstone Ltd. 30s.

The Discovery of Reflexes. By E. G. T. LIDDELL, D.M., F.R.S., Waynflete Professor of Physiology, The University of Oxford. 9½ × 6 in. Pp. 174 + viii. 1960. Oxford: The Clarendon Press. (London: Oxford University Press.) 30s.

Christopher's Textbook of Surgery. Edited by LOYAL DAVIS, M.D., Chairman of the Department of Surgery, Northwestern University Medical School. Seventh edition. 10 × 6¾ in. Pp. 1551 + xx, with 1597 illustrations on 810 figures. 1960. Philadelphia and London: W. B. Saunders Co. £5 19s.

Cole and Elman's Textbook of Surgery. Edited by WARREN H. COLE, M.D., Professor and Head of the Department of Surgery, University of Illinois College of Medicine; Chief Surgeon, Illinois Research and Educational Hospitals, Chicago. Seventh edition. 10 × 6¾ in. Pp. 1224 + xxi, illustrated. 1960. London: Staples Press. £7 7s.

Radiology as a Diagnostic Aid in Clinical Surgery. By HOWARD MIDDLEMISS, M.D., F.F.R., D.M.R.D., Director of Radiology, United Bristol Hospitals; Lecturer-in-Charge, Department of Radiodiagnosis, University of Bristol. 9½ × 6½ in. Pp. 151 + vi, with 86 illustrations. 1960. London: William Heinemann Ltd. 30s.

An Atlas of Neurosurgical Techniques. By JAMES L. POPPER, M.D., Neurosurgeon, The Lahey Clinic, New England Baptist Hospital, New England Deaconess Hospital. 10¾ × 7¾ in. Pp. 522 + xii, with 248 plates. 1960. Philadelphia and London: W. B. Saunders Co. £9 16s.

Butterworth Books for Surgeons

GENERAL ANAESTHESIA

Edited by FRANKIS T. EVANS, M.B., B.S., F.F.A.R.C.S., D.A., and CECIL GRAY, M.D., F.F.A.R.C.S. In two volumes: Vol. I, Pp. xiv+531+Index; Vol. II, Pp. xii+431+Index. 199 illustrations. **£7 7s.** net per set, by post **2s. 9d.** extra.

The whole wide field of anaesthesia is covered in these two volumes. The first takes in basic principles, covering those specialized aspects of anatomy, physiology and neurophysiology which are important to anaesthetists in their everyday work, pre-anaesthetic considerations, apparatus, blood transfusions, the different methods of administration and many other subjects. Techniques, special fields and hazards are detailed in the second, where the appropriate anaesthetic approach to every type of operation is minutely examined by accepted authorities writing on their own subjects.

PRINCIPLES OF BONE X-RAY DIAGNOSIS

By GEORGE SIMON, M.D., M.R.C.P., F.F.R.
Pp. xx+170+Index. 244 illustrations. **57s. 6d.** net, by post **1s. 9d.** extra.

Again the author has used the method of classifying the abnormalities shown on the X-ray and then linking a provisional or even final diagnosis with the clinical findings. In this way the study of the lesion on the film may indicate the proper laboratory investigations to be performed and reduce the list of possible diagnoses to manageable proportions. Essentially for the radiologist, this book will also be welcomed by orthopaedic surgeons, doctors and by students who may be learning to interpret the appearances on bone X-rays.

MODERN TRENDS IN ACCIDENT SURGERY AND MEDICINE

Edited by RUSCOE CLARKE, M.B.E., M.B. (Lond.), F.R.C.S. (Eng.), F. G. BADGER, B.Sc., F.R.C.S. (Ed.), and SIMON SEVITT, M.D., M.Sc., M.A., F.R.C.P.I., D.P.H. Pp. xi+330+Index. 82 illustrations. **75s.** net, by post **1s. 9d.** extra.

"It is pleasing that the title of this book is comprehensive, including both surgical and medical accidents; this is as it should be, as a modern understanding of accident cases involves the patient as a whole. Every aspect of the accident case is covered in a very practical way. . . . The illustrations are excellent and have been well chosen. The operative treatment of fractures is portrayed in a very interesting and practical fashion. This is one of the really important books of the year. It will be the guide to all surgeons who have to deal with trauma and it will prove of real value to the surgical undergraduate who is working for a higher degree."—*British Journal of Surgery.*

MODERN TRENDS IN DISEASES OF THE VERTEBRAL COLUMN

Edited by REGINALD NASSIM, B.M., F.R.C.P., and H. JACKSON BURROWS, M.D., F.R.C.S., F.R.A.C.S. Pp. ix+292+Index. 172 illustrations. **75s.** net, by post **2s.** extra.

This book highlights that field of advancing knowledge in which primary disease may either cause a spinal condition directly or affect the spine indirectly. The inter-relation between these two processes is discussed, diagnostic and therapeutic procedures are evaluated and the anatomy comprehensively reviewed in the light of present knowledge.
". . . interesting, informative and an outstanding addition to surgical literature".—*British Medical Journal.*

Full details and illustrated catalogue available on application

BUTTERWORTHS, 88 KINGSWAY, LONDON, W.C.2
Showroom: 11–12 BELL YARD, TEMPLE BAR, LONDON, W.C.2

H. K. Lewis & Co. Ltd.

Medical Publishers and Booksellers

136 GOWER STREET LONDON, W.C.1

(Adjoining University College and Hospital)

Telephone: EUSton 4282 (9 lines).
Telegrams: Publicavit, Westcent, London.
Established 1844.

Medical Lending Library

Annual Subscription from £1 17s. 6d.

Prospectus post free on application

Bi-monthly List of New Books and New Editions added to the Library sent post free on request

THE LIBRARY CATALOGUE revised to December, 1956, containing a Classified Index of Authors and Subjects.

Subscribers **£1 5s.** net. Non-subscribers **£2 2s.** net.
Postage **2s.**

NEW BOOKS ADDED IMMEDIATELY UPON PUBLICATION

THE WORLD'S GREATEST BOOKSHOP

FOYLES

* * FOR BOOKS * *

STOCK OF OVER 4 MILLION VOLUMES

BIG DEPARTMENT FOR MEDICAL BOOKS

Many medical men tell us that it is the best medical books department in London

119-125 CHARING CROSS ROAD LONDON WC2.

Gerrard 5660 (20 *lines*) ★ *Open* 9–6 (*incl. Sats.*)

NEAREST STATION: TOTTENHAM COURT ROAD

Poppen—ATLAS OF NEUROSURGICAL TECHNIQUES

Exquisite, step-by-step pictorial details of procedures in elective and emergency neurosurgery—drawn from the author's long experience at the Lahey Clinic

By **JAMES POPPEN,** Neurosurgeon, The Lahey Clinic

522 pages, with 248 full-page plates **£9 . 16 . 0**

This new atlas visually demonstrates the operative procedures used by Dr. Poppen at the Lahey Clinic for the investigation, correction and management of surgical disorders of the nervous system. Large, full-page illustrative plates (with concise operative instructions on the facing page) show and describe the step-by-step details of today's highly effective neurosurgical techniques.

The contents are divided into 6 parts: Part 1 on THE HEAD describes cranial, intracranial and extracranial procedures. Part 2 covers procedures of THE NECK and contiguous areas. Part 3 delineates measures in THE CHEST AND ABDOMEN. Part 4 covers peripheral disorders in THE EXTREMITIES. Part 5 delves into problems of THE SPINE, and Part 6 describes NEUROSURGICAL DIAGNOSIS, including such procedures as Sinography and Turkel Bone Biopsy of the Skull.

Neurosurgeons, general and orthopedic surgeons will value this atlas highly, because it illustrates so minutely the techniques of neurosurgery—from initial incision to final closure.

W. B. SAUNDERS COMPANY LIMITED • **7 GRAPE STREET LONDON, W.C.2**

E. & S. LIVINGSTONE, LTD.

SURGERY AND CLINICAL PATHOLOGY IN THE TROPICS

By Charles Bowesman, O.B.E., B.A., M.D., F.R.C.S.E., F.A.C.S., D.T.M. & H.ED.

1,076 pages. 381 illustrations. £5 10s.

BODY FLUIDS IN SURGERY

Second Edition. By A. W. Wilkinson, CH.M., F.R.C.S.E., F.R.C.S.

288 pages. 22 illustrations. 21s.

SURGERY OF REPAIR AS APPLIED TO HAND INJURIES

Second Edition. By B. K. Rank, C.M.G., M.S. (MELB.), F.R.C.S., F.R.A.C.S., and A. R. Wakefield, M.S. (MELB.), F.R.C.S., F.R.A.C.S.

298 pages. 486 illustrations. 45s.

ESSAYS ON THE FIRST HUNDRED YEARS OF ANÆSTHESIA

By W. Stanley Sykes, M.B.E., M.A., M.B., B.CHIR., D.A.

171 pages. 68 illustrations. 30s.

A CLINICAL PROSPECT OF THE CANCER PROBLEM

By D. W. Smithers, M.D., F.R.C.P., F.F.R.

248 pages. 70 illustrations. 37s. 6d.

This book forms the introductory volume to the important series on "Neoplastic Disease at Various Sites" which is under the General Editorship of Professor Smithers.

Fractures and Joint Injuries

Fourth Edition Third Reprint. Sir Reginald Watson-Jones. In two volumes. £6 10s.

The Cell of Schwann

Professor Gilbert Causey. 21s.

Peptic Ulceration

Professor Charles Wells and James Kyle. 42s.

Fundamental Techniques of Plastic Surgery and their Surgical Application

Ian A. McGregor. 30s.

Outline of Orthopædics

Third Edition. J. Crawford Adams. 35s.

Surgical Treatment of Bone and Joint Tuberculosis

R. Roaf, W. H. Kirkaldy-Willis and A. J. M. Cathro. 30s.

A Catalogue of the Portraits and other Paintings, Drawings and Sculpture in the Royal College of Surgeons of England

W. R. LeFanu. 30s.

TEVIOT PLACE, EDINBURGH

Baillière, Tindall & Cox

ROSE & CARLESS: Manual of Surgery

Consulting Editor: Sir Cecil Wakeley, Bt., K.B.E., C.B., LL.D., M.Ch., D.Sc., F.R.C.S., F.R.S.E., F.R.S.A., F.A.C.S., F.R.A.C.S.

Editors: Michael Harmer, M.A., M.B., B.Chir. (Cantab.), F.R.C.S., and Selwyn Taylor, M.A., D.M., M.Ch. (Oxon.), F.R.C.S.

Nineteenth Edition. 1404 pages. 940 illustrations. **84s.** Postage **2s. 9d.**

PEER: Transplantation of Tissues, Volume 2

by L. A. Peer, M.D., with twelve contributors

704 pages. 252 illustrations. **160s.** Postage **2s. 9d.**

Volume I is available **108s.** Postage **2s. 9d.**

GLASSMAN & McNEALY: Care of the Surgical Patient

by J. A. Glassman, M.D., F.A.C.S., F.I.C.S., and R. W. McNealy, M.D., F.A.C.S., F.I.C.S.

352 pages. 2 illustrations. **52s.** Postage **2s. 6d.**

KAZANJIAN AND CONVERSE:

The Surgical Treatment of Facial Injuries

by V. H. Kazanjian, M.D., and J. M. Converse, M.D.

1117 pages. 1155 illustrations (10 in colour). **176s.** Postage **2s. 9d.**

BECHTOL, FERGUSON AND LAING:

Metals and Engineering in Bone and Joint Surgery

by C. O. Bechtol, M.D., A. B. Ferguson, Jr., M.D., and P. G. Laing, M.B., B.S., F.R.C.S.

210 pages. 123 illustrations. **64s.** Postage **2s. 9d.**

7 & 8 HENRIETTA STREET, LONDON, WC2

now available

the new STANLEY COX SURGICAL DIATHERMY

for

GENERAL AND NEUROLOGICAL SURGERY

Special Circuits ensure

Speedy coagulation with no charring.

Speedy cutting without excessive coagulation *and* **Bipolar Coagulation** using special forceps electrode supplied, coagulating current affects the tissue between the electrode tips with little effect on surrounding tissue and practically no tendency to deep clotting in blood vessels.

Cautery output: up to 40 amps.

Light output: 0-4 volts fixed.
0-12 volts variable
in steps of 1 volt.

Please send for full details

STANLEY COX LIMITED
Medical Division, **Electrin House**
93/97, New Cavendish Street, London, W.1.
Telephone: **LANgham 4551/6**
Telegrams: **Stanlicox-Wesdo**

Two Important New Editions

Ready in June

Demonstrations of PHYSICAL SIGNS IN CLINICAL SURGERY

13th Edition

By HAMILTON BAILEY. 944 pp. 1,142 illustrations, a very large number in colour. **75s., post 2s. 3d.**

Completely revised and its scope enlarged; nearly double the amount of text and twice the number of illustrations. The illustrations have always been considered to be of prime importance and for the new edition many have been replaced, many added, and those retained have in the main been remade. The new edition will indeed not only maintain its position but very greatly enhance it. It would be difficult to imagine a finer book.

FRENCH'S INDEX OF DIFFERENTIAL DIAGNOSIS

8th Edition

Edited by ARTHUR H. DOUTHWAITE. 1123 pp. 731 illustrations, many in colour. **126s., post 2s. 6d.**

The whole ground of Medicine, Surgery, Gynaecology, Ophthalmology, Dermatology, and Neurology is covered thoroughly and clearly, making the work a treasure-house of information indispensable to specialist and general practitioner alike. For the new edition much revision and re-writing has been undertaken, and new material and illustrations have been added, bringing the book thoroughly up to date.

WRIGHT'S of BRISTOL

Additions to the range of

PARAGON
scalpel handles and blades

BLADES IN PACKETS OF 6
HANDLES PACKED SINGLY

Obtainable from all the leading Supply Houses.

Sole Manufacturers: THE PARAGON RAZOR CO., SHEFFIELD, ENGLAND

HENRY KIMPTON'S PUBLICATIONS

New (4th) Edition — Just Ready

THE FOOT AND ANKLE

Injuries, Diseases, Deformities and Disabilities

By **PHILIP LEWIN,** M.D., F.A.C.S., F.I.C.S.

FOURTH EDITION, REVISED

9½ × 6¼ in. — 612 pages — 339 illustrations — Cloth — Price **£5 5s.** net

New Book — Now Ready

CARE OF MINOR HAND INJURIES

By **ADRIAN E. FLATT,** M.A., M.D., F.R.C.S.

9¾ × 6¼ in. — 266 pages — 109 illustrations — Cloth — Price **71s. 6d.** net

New Book — Just Ready

INSTRUCTIONAL COURSE LECTURES—1959—16th Volume

from the AMERICAN ACADEMY OF ORTHOPEDIC SURGEONS

Edited by **FREDERICK C. REYNOLDS,** A.B., M.D.

10¾ × 8¼ in. — 320 pages — 260 illustrations — Cloth — Price **£6** net

New (3rd) Edition — Now Ready

OFFICE ORTHOPEDICS

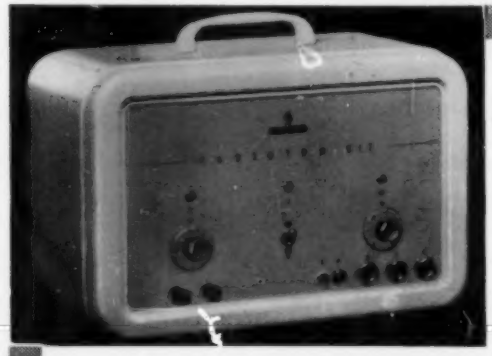
By **LEWIS COZEN,** M.D., F.A.C.S.

THIRD EDITION, REVISED AND ENLARGED

9½ × 6¼ in. — 430 pages — 321 illustrations — Cloth — Price **70s.** net

134 Gt. Portland Street — **HENRY KIMPTON** — **London, W.1**

Medical Book Department of Hirschfeld Brothers, Ltd.



For modern electro-surgery techniques

RADIOTOM 612

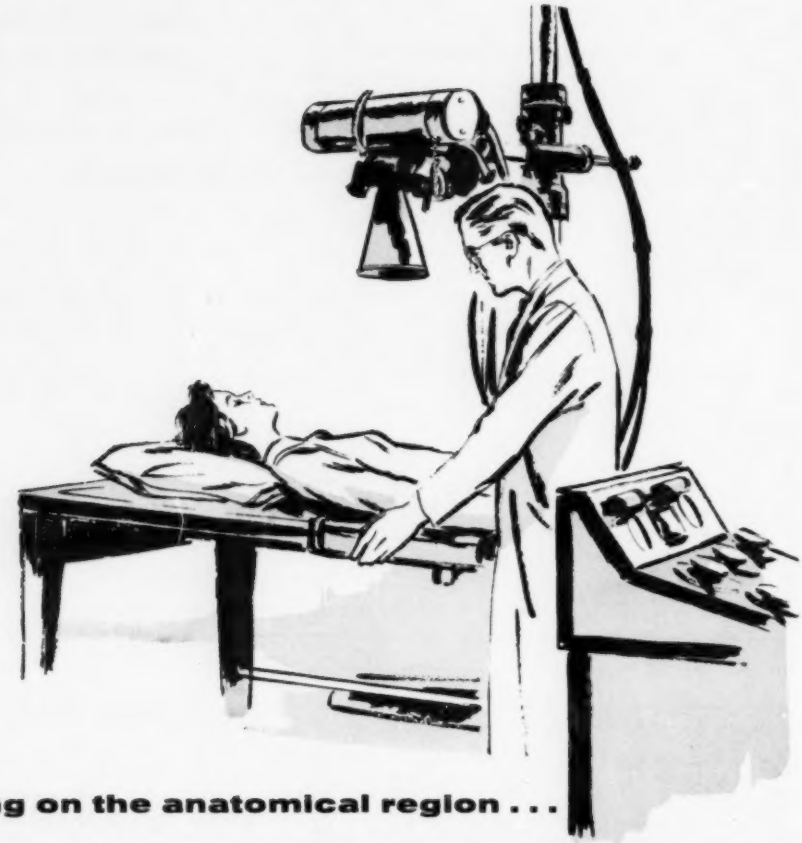
* Wide range of application, from neurosurgery to urology.
* Cutting: needle and lancet electrodes; wire and band loop electrodes.
* Coagulation: ball electrodes up to 5mm dia; plate electrodes up to 100 sq. mm.
* Endoscopy: up to 12 volts, 1 amp, continuously adjustable.
* Special safety circuit prevents accidental burns to patient.

Write or telephone for full details

SIEREX LTD

241 Tottenham Court Road London W1

Telephone: LANgham 2464



Depending on the anatomical region . . .

Depending on the technique to be employed . . .

Depending on the radiological requirements . . .

You will choose

ILFORD RED SEAL · STANDARD · ILFEX

Get to know these ILFORD X-ray films

ILFORD X-ray films are made to specifications drawn up by technicians who are in constant touch with *your daily problems.*

ILFORD LIMITED · ILFORD · ESSEX

An essential precaution against cross-infection

"The noses of healthy individuals probably form by far the largest breeding ground for the pathogenic staphylococci."

Brit. med. J. 1959, *ii* 658

'Naseptin' Nasal-Carrier Cream has been shown to be the most effective preparation for preventing colonisation of the nose with pathogenic hospital strains of staphylococci.

The routine twice daily application of 'Naseptin' will prevent patients from becoming carriers of these organisms. For established nasal carriage amongst hospital staff, more frequent applications of 'Naseptin' are recommended.

ADVANTAGES

- Easy and pleasant to use.
- Maximum effectiveness.
- Resistant strains have not been encountered nor is resistance likely to be induced.
- Sensitivity reactions are most unlikely to occur.
- Treatment is extremely cheap.

Naseptin
TRADE MARK
NASAL-CARRIER CREAM

ICI

Contains 'Hibitane' (Chlorhexidine) Hydrochloride B.P.C. 0.1% and Neomycin Sulphate B.P. 0.5%.

Issued in tubes of 5 grammes. Basic N.H.S. cost 2/4d.
Literature is available on request.

IMPERIAL CHEMICAL INDUSTRIES LIMITED
Pharmaceuticals Division Wilmslow Cheshire Ph.14

for
r
ph

The new 'Kodak' Technical Close-Up Kit fitted to a Kodak Bantam 'Colorsnap' Camera.

The 'Kodak' Technical Close-Up Kit provides a simple means of taking medical close-up photographs at 7 inches or 3 feet. It can also be used for full-length subjects. It can be fitted to the Kodak Bantam 'Colorsnap' camera, the Kodak 'Retinette' camera or 'Retina' Ib, IIc or IIIc cameras.

The kit consists of:

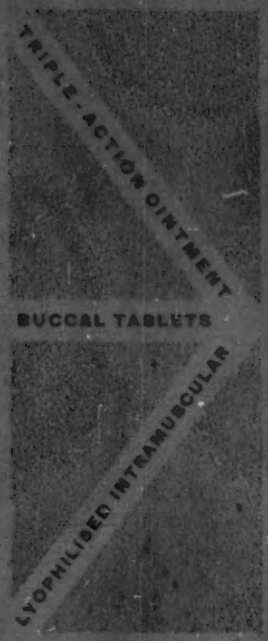
1. 'Kodak' Technical Close-Up Frame. The field size of $3\frac{1}{4} \times 4\frac{3}{4}$ in. at 7 in. is marked on the L-shaped field frame. (For the 'Retina' cameras the field size is $3 \times 4\frac{1}{4}$ in.) A marker on the short leg of the frame corrects for parallax in 3-ft. shots.
2. 'Portra' Lens +5 (5 dioptres) in 'Kodisk' Mount. This is 'Lumenized' for maximum light transmission.
3. 'Kodak' Flasholder Model II with camera bracket and cable.
4. 'Kodak' Flash Cover — a soft plastic bag which fits over the Flasholder. The colour and dispersive powers of the material are such as to give correct exposure and colour rendering when used with PF 1/97 flashbulbs, or their equivalent, and 'Kodachrome' Film Daylight Type at 7-in. subject distance.
5. An instruction manual.

A leather carrying case can also be supplied. Of 'doctor's bag' pattern, it takes the complete outfit (with camera), films and flashbulbs.

Please ask for full details.

Kodak Limited, Medical Sales Division, Kingsway, London, W.C.2.

'Kodak' is a registered trade-mark.



CONTROLS INFLAMMATION
RELIEVES PAIN
PROMOTES HEALING

ARMOUR

at any site

CHYMAR

CHYMOTRYPSIN

PRODUCTS OF ARMOUR RESEARCH

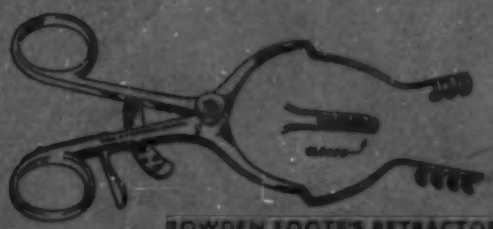
Beneficial in the management of accidental, surgical, gynaecological trauma; inflammatory skin and eye diseases; respiratory and gastro-intestinal tract inflammations; thrombophlebitis; and any conditions where inflammation, swelling and pain hinder healing.

ARMOUR PHARMACEUTICAL COMPANY LTD | EASTBOURNE · ENGLAND

VARICOSE VEIN SURGERY

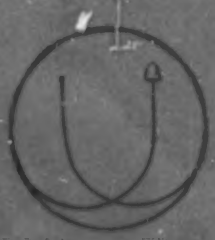
ROWDEN FOOTE'S RETRACTOR
With Solid Blade

DICKSON WRIGHT'S RETRACTOR
With stainless steel wire blade



ROWDEN FOOTE'S RETRACTOR
Self-retaining (Vide B.M.J. 27.7.46.)

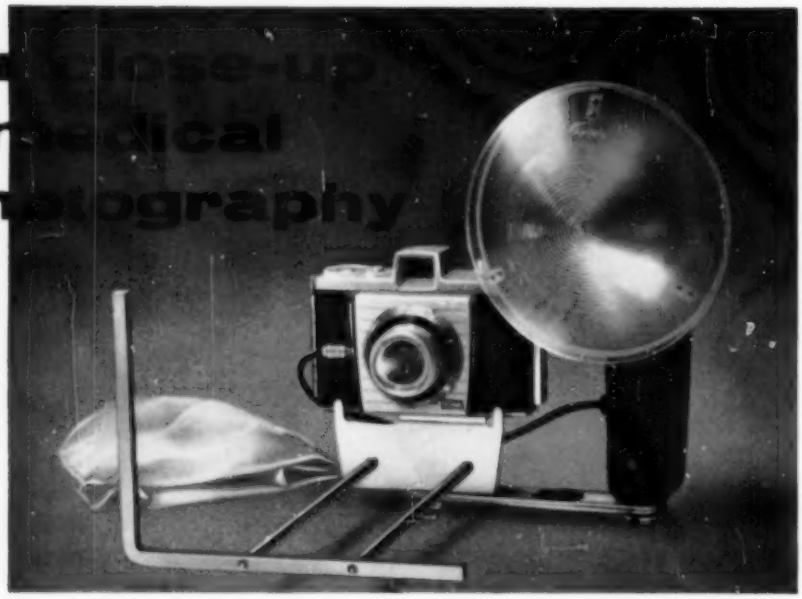
MYERS VEIN STRIPPER
36" spiral wire with ⅛" or ¼" diameter acorn head. (Vide "Varicose Veins" 2nd edition, 1954. R. Rowden Foote, page 152). Also, double ended model with two detachable screw-on heads, as used by Mr. R. Rowden Foote. **Now available.**



Write for new illustrated brochure of Instruments and Equipment used in the treatment of Varicose Veins and Ulcers.

JOHN BELL & CROYDEN *MAKERS OF SURGICAL INSTRUMENTS & APPLIANCES*
WIGMORE STREET, LONDON, W.1 'Phone: WELbeck 5555

for close-up medical photography



The new 'Kodak' Technical Close-Up Kit fitted to a Kodak Bantam 'Colorsnap' Camera.

The 'Kodak' Technical Close-Up Kit provides a simple means of taking medical close-up photographs at 7 inches or 3 feet. It can also be used for full-length subjects. It can be fitted to the Kodak Bantam 'Colorsnap' camera, the Kodak 'Retinette' camera or 'Retina' Ib, IIc or IIIc cameras.

The kit consists of:

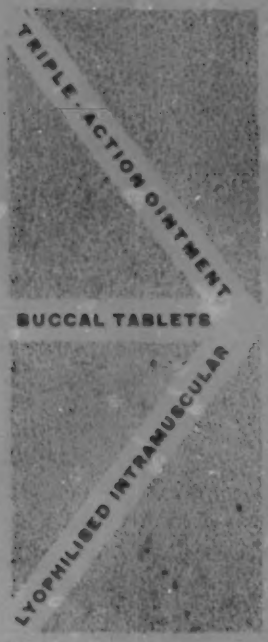
1. 'Kodak' Technical Close-Up Frame. The field size of 3¼ × 4¾ in. at 7 in. is marked on the L-shaped field frame. (For the 'Retina' cameras the field size is 3 × 4¼ in.) A marker on the short leg of the frame corrects for parallax in 3-ft. shots.
2. 'Portra' Lens + 5 (5 dioptres) in 'Kodisk' Mount. This is 'Lumenized' for maximum light transmission.
3. 'Kodak' Flasholder Model II with camera bracket and cable.
4. 'Kodak' Flash Cover — a soft plastic bag which fits over the Flasholder. The colour and dispersive powers of the material are such as to give correct exposure and colour rendering when used with PF 1/97 flashbulbs, or their equivalent, and 'Kodachrome' Film Daylight Type at 7-in. subject distance.
5. An instruction manual.

A leather carrying case can also be supplied. Of 'doctor's bag' pattern, it takes the complete outfit (with camera), films and flashbulbs.

Please ask for full details.

Kodak Limited, Medical Sales Division, Kingsway, London, W.C.2.

'Kodak' is a registered trade-mark.



CONTROLS INFLAMMATION
RELIEVES PAIN
PROMOTES HEALING

ARMOUR

at any site

CHYMAR

CHYMOTRYPSIN

PRODUCTS OF ARMOUR RESEARCH

BENEFICIAL in the management of accidental, surgical, gynaecological trauma; inflammatory skin and eye diseases; respiratory and gastro-intestinal tract inflammations; thrombophlebitis; and any conditions where inflammation, swelling and pain hinder healing.

ARMOUR PHARMACEUTICAL COMPANY LTD | EASTBOURNE · ENGLAND

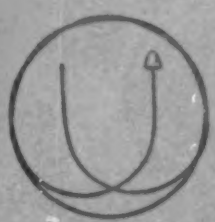
VARICOSE VEIN SURGERY

ROWDEN FOOTE'S RETRACTOR
With Solid Blade

DICKSON WRIGHT'S RETRACTOR
With stainless steel wire blade

ROWDEN FOOTE'S RETRACTOR
Self-retaining (Vide B.M.J. 27.7.46.)

MYERS VEIN STRIPPER
36" spiral wire with ⅜" or ½" diameter acorn head. (Vide "Varicose Veins" 2nd edition, 1954. R. Rowden Foote, page 152). **Also** double ended model with two detachable screw-on heads, as used by Mr. R. Rowden Foote. **Now available.**



Write for new illustrated brochure of Instruments and Equipment used in the treatment of Varicose Veins and Ulcers.

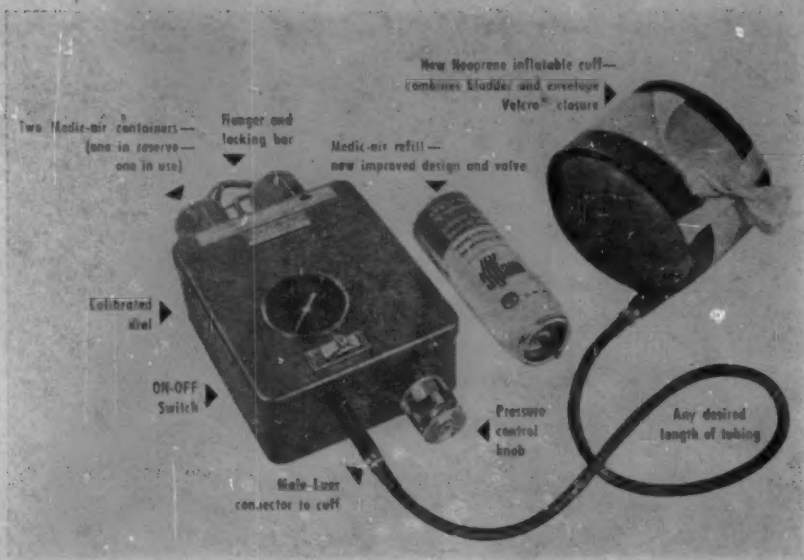
JOHN BELL & CROYDEN *MAKERS OF SURGICAL INSTRUMENTS & APPLIANCES*
WIGMORE STREET, LONDON, W.1 'Phone': WELbeck 5555

Kidde TOURNIQUET

Automatically Regulated OPERATING ROOM MODEL

Made in U.S.A.

- **permits rapid application of pressure**
- **maintains desired pre-set pressure at from zero to 1,000 mm. mercury until change is desired**
- **allows controlled variations in pressure as needed during lengthy procedures**


New Neoprene inflatable cuff—combines bladder and envelope
Velcro® closure
Two Medic-air containers—(one in reserve—one in use)
Hanger and locking bar
Medic-air refill—new improved design and valve
Calibrated dial
ON-OFF Switch
Pressure control knob
Any desired length of tubing
Male Luer connector to cuff

The Kidde Tourniquet hangs conveniently at operating table or bedside. Pressure is pre-set before applying to the patient and is constant until release or adjustment is desired. Inflation is rapid but release of pressure is gradual to avoid shock of too sudden drop. Gas used for inflation is nontoxic, noninflammable.

Supplied by

DOWN BROS. and MAYER & PHELPS Ltd.

CHURCH PATH · MITCHAM · SURREY

Tel: MITcham 6291

32 New Cavendish Street, London, W.1. Tel: WELbeck 3764

21 St. Thomas Street, London, S.E.1. Tel: HOP 4141

PRINTED IN GREAT BRITAIN BY JOHN WRIGHT AND SONS LTD., AT THE STONEBRIDGE PRESS, BRISTOL